CASE

Power from manure and slaughterhouse waste for industry's internal use (SuKarne, Mexico)

Javier Reynoso-Lobo, Krishna C. Rao, Lars Schoebitz and Linda Strande

Supporting case for Business Model 5	
Location:	Culiacan, State of Sinaloa, Mexico
Waste input type:	Animal and slaughterhouse waste
Value offer:	Biogas to electricity and thermal energy, bio-diesel, compressed Bio-gas, carbon credits and organic bio-fertilizer
Organization type:	Private
Status of organization:	Commercial-scale project under construction
Scale of businesses:	Large
Major partners:	Alberta Innovates–Technology Futures (Technology), Pro Bio (Fertilizer distributor, the group company), National Electricity Commission (Interconnection), United Nations (Carbon market), National Science and Technology Council (Research funding), IGSA (Co-investor[1]), German Biogas Company (Project design and management[2])

Executive summary

Grupo Viz (GV), a family business in the commercial cattle industry, was established in 1969 in Mexico. SuKarne, one of the five business entities of GV group, with annual sales of over USD 2 billion is the third largest feedlot grain-fed company in the world and fifth largest beef provider in North America. SuKarne's business chain produces both animal and slaughter waste, and it sells some of the waste to its affiliated companies (also owned by GV). In 2012, SuKarne began construction of a biogas pilot plant, a first for the cattle industry that uses a mixture of animal waste and residual biomass, with the lagoon's water, to produce biogas for electricity and thermal energy. At full capacity, it is expected to generate approximately 3.2 MW of electricity for self-consumption and 3 MJ to displace boiler diesel with the heat generated. It will also be possible to further treat the biogas to produce liquid fuel or compressed gas to feed the trucks used throughout the whole operation. The plant will also generate organic bio-fertilizer to be sold to an affiliated company. The project was at the time of assessment under commercial-scale development and expected for construction and commissioning in 2015, with possibilities to replicate the model in its other four facilities in Mexico. The plan is that each plant will be self-sufficient in both electricity and thermal energy. The project's feasibility study is registered

in the Clean Development Mechanism (CDM) and subject for final approval for a Certified Emission Reductions (CERs) agreement.

KEY PERFORMANCE INDICATORS FOR THE CULIACAN FACILITY (AS OF 2014)						
Water:	67,000 m^3 of slaughterhouse wastewater reutilized per annum					
Capital investment:	USD 12.5 million					
Labor:	9 employees (O&M supervisor, mechanic/electric engineers, 5 operators, 1 technician)					
O&M cost:	Approx. USD 90,000 per annum					
Output:	110,000 tons of animal waste processed per annum to generate 13 million m^3 biogas per annum, or 3.2 MW as electricity and 3 MJ as heat using a combined heat and power (CHP) unit, and approx. 35,000 tons of vermicomposting per annum					
Potential social and/or environmental impact:	Yearly savings of approx. USD 1.8 million in diesel and electricity costs, reduction of approx. 132,000 tons of equivalent CO_2 emissions per annum (US-EPA calculator), generation of a renewable source of energy for the company; Reduced soil, water and air pollution					
Financial viability indicators:	Payback period:	2.9 years	Post-tax IRR:	14.3 %	Gross margin:	USD 4.28 million

Context and background

GV is a family business established in 1969 at Culiacan, Sinaloa. Over the years, GV expanded its operation to other parts of the cattle production business value chain and now owns five subsidiary companies operating independently. The five subsidiaries of GV are: a) SuKarne Agro-industrial, a beef, poultry and pork producer, b) Rendimientos Protéicos (Renpro), specializes in processing of tallow, meat and blood meals for livestock and animal feed production, c) Productos Bioorgánicos (ProBio), specializes in the production of organic compost and vermicomposting from animal waste, d) SuKuero, specializes in leather commercialization and e) Agrovizion, an agribusiness dedicated to the promotion and commercialization of agricultural products such as corn, wheat, oats and roughage. This case study is on SuKarne, the largest producer and supplier of beef in Mexico, third largest feedlot grain-fed company in the world and fifth largest beef provider in North America. SuKarne owned at the time of assessment five production facilities around the country, located in the states of Nuevo Leon, Baja California, Michoacan, Durango and Sinaloa. These five facilities maintain a daily average of 425,000 animals confined in open feedlots through the year, and approximately 1,100,000 animals are processed per annum.

Manure is removed from the feedlots twice a year using a scraping system and disposed in piles over lands located near the operation for further degradation through composting processes. Mexican and local state legislation prohibit the unlicensed displacement and/or uncontrolled burning of animal waste, which leaves a huge amount that is left to decay on the ground, thus contributing to the greenhouse gas (GHG) emissions to the atmosphere.

A business opportunity was identified by SuKarne to develop a methane recovery project from the animal waste generated in their five facilities and generate thermal and electric energy in the form of biogas along with organic material for compost, while significantly reducing GHG emissions. In late 2012, SuKarne constructed a dry fermentation pilot plant and throughout 2013 conducted a series of trials which validated the feasibility of the technology and its waste streams for biogas production.

SuKarne is developing the commercial-scale project with Canadian biogas plant providers to construct a large biogas facility near its operation in Culiacan. Prior to this initiative, SuKarne sold its

organic waste (feedlot manure) to Pro Bio to produce organic compost and vermicomposting. This case study focuses on the business model for the biogas production facility under development. The project will use animal waste and slaughterhouse waste as feedstock to produce biogas (mainly containing methane). The biogas will be used to generate electric and thermal energy. The expected amount of GHG emissions reduction with the project is on average 132,000 tons of CO_2-eq per annum.

SuKarne's biogas operations and its end users are within its premises or with affiliated companies, and hence there is no competition for procuring waste or sale of energy. The fertilizer produced from the bio-methanation process will be exclusively sold to Pro Bio, an affiliated company in the business of producing organic compost.

Market environment

According to the Mexican Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA), 58% of Mexico's land, a total of 113.8 million hectares, is used for beef production. There is a total of 31 million cattle livestock in Mexico owned by 1.13 million breeders: 2 million dairy cattle and 29 million beef cattle. According to the Mexican Ministry of Environment and Natural Resources (SEMARNAT), livestock production has shown an accelerated growth in the past two decades, increasing by 62% in comparison with the 1990s. As a result of this progressive increase in livestock production, 83% of Mexico's emissions from agricultural sector were attributed to livestock production in 2002, equivalent to 8% of the total emissions in Mexico (Table 19). However, the consumption of fossil fuels accounts for 63% of the country's carbon emissions, and a major part of the carbon emissions are from agro-industrial operations such as meat production. There has been no significant action in terms of emission reduction from this part of the livestock sector. Other sectors such as swine farms have developed projects with the support of government programs such as Methane to Markets (M2M) and the CDM, though most account only as far as for biogas burning. So far, there are no other business models in the Mexican livestock industry that transform waste into self-supplied renewable energy at commercial-scale.

TABLE 19. MEXICO EMISSIONS IN CO_2 EQUIVALENT (GG), ADAPTED FROM "METHANE TO MARKETS." SOURCE: SEMARNAT, 2008

EMISSION CATEGORY	2002	PERCENTAGE
1) Energy	389,496.70	70.39%
1A) Consumption of fossil fuel	350,414.30	89.97%
1B) Fugitive methane emissions	39,082.30	10.03%
2) Industrial processes	52,102.20	9.41%
3) Agriculture	46,290.80	8.36%
3A) Livestock	38,527.47	83.23%
3B) Crops	7,763.26	16.77%
4) Waste	65,584.40	11.84%
Total	**553,329.40**	**100%**

Macro-economic environment

The livestock operations are prone to serious environmental impacts, such as GHG emissions, odor and water and land contamination, all a result from storage and disposal of animal waste. Confined Animal Feeding Operations (CAFOs) use similar Animal Waste Management System (AWMS) options

to store animal residues. These systems emit both methane (CH_4) and nitrous oxide (N_2O) resulting from aerobic and anaerobic decomposition processes (Clean Development Mechanism, 2007). Since approval of the Kyoto Protocol, immense interest in methane recovery has been generated amongst large-scale farms and livestock producers in Mexico, many of who have registered CDM projects.

In addition, Mexico created a strong climate change and renewable energy law in 2012 that targets 30% lower emissions compared to business as usual by 2020 and 50% by 2050.

Business model

SuKarne's methane recovery project has three key value propositions (Figure 60) – production of biogas to generate electricity and heat for self-consumption (displacing electricity purchase from the national grid and diesel costs for boilers and trucks), production of solid/liquid fertilizer from the effluent of the bio-methanation process and sale to Pro Bio and sale of carbon offset both from methane recovered and fossil fuel displacement.

It is key for SuKarne to ensure that all waste generated from its business value chain is brought to the biogas facility. SuKarne partnered with a Canadian technology research centre to help develop the biogas technology to process multiple feedstocks in the biogas digester. The most critical relationships for SuKarne in its methane recovery project is its partnership with co-investor IGSA, biogas plant providers for the design and project management of the facility construction, the national grid for interconnection and electricity supply contracts, affiliates such as Pro Bio for sale of solid/liquid fertilizer and carbon companies buying CER certificates.

Value chain and position

SuKarne manages livestock procurement and production, meat processing, distribution and commercialization (Figure 61). SuKarne captures organic waste generated from several parts of its chain and transforms it to higher-value products such as leather, animal feed, soaps, organic compost and vermicomposting, and with the implementation of this project into biogas as well. The biogas model will merge into the existing model by reutilizing the feedlot manure from the pens, corn stover from the feed mill and paunch content and wastewater from the slaughterhouse to generate renewable energy which will replace fuel and electricity supply used in one of its operations. The composting process in the value chain will shift to take place after the biogas production process.

Institutional environment

Regulatory settings in Mexico require businesses to prepare an environmental impact assessment of the proposed energy generation plants in order to demonstrate that it will not have a negative impact on the environment. This is currently regulated by SEMARNAT. Additionally, every business that intends to generate and/or sell energy must be regulated by the Electricity and Hydrocarbons Regulator (CRE). They grant permits for private self-supply generation, independent power production and co-generation. The CRE has designed several instruments which regulate the relationship between suppliers (Federal Energy Commission and Light and Power Company) and private generators.

Mexico has a progressive policy on climate change and renewable energy commitment to meet its optimistic targets. However, the government will likely have to provide more fiscal incentives. The General Law for Climate Change adopted in May 2012 sets the goal of 35% of energy generated in the country should come from renewable sources by 2024. The law creates a fund for the transition to clean and renewable energy and technologies. These legal instruments are expected to create a better framework to support renewable energy in general and also a future green economy in Mexico. Additionally, implementation of renewable energy reinforcement laws and incentives schemes as well

FIGURE 60. SUKARNE METHANE RECOVERY BUSINESS MODEL CANVAS

KEY PARTNERS

- Local breeders
- Grupo Viz subsidiaries (waste suppliers)
- Federal electricity commission
- Carbon investors
- Biogas technology developer
- Biogas plant provider

KEY ACTIVITIES

- Collection of animal and agro waste
- Production of biogas
- Electricity cogeneration and heat usage
- Production of bio-diesel or compressed biogas
- Production of organic compost
- O&M for production

KEY RESOURCES

- Slaughterhouse waste
- Dry fermentation technology
- Contracts with electricity commission
- Capital investment

VALUE PROPOSITIONS

- Recovery of methane from animal and slaughterhouse waste to create carbon offsets
- Production of biogas for heat and electricity
- Production of solid/liquid fertilizer

CUSTOMER RELATIONSHIPS

- Direct interaction carbon trading companies
- Internal and direct interaction with electricity commission
- Direct interaction and partnership

CHANNELS

- Long term contract agreements

CUSTOMER SEGMENTS

- Carbon trading company
- Grupo Viz subsidiaries (for internal consumption of electricity as well as thermal energy)
- National grid
- Fertilizer affiliate company

COST STRUCTURE

- Investment cost (engineering, construction, equipment, commissioning, cogeneration, transmission)
- Operational cost (labor, maintenance cost, energy, fuel)
- Depreciation
- Savings from energy displacement, both electricity as well as diesel

REVENUE STREAMS

- Sales of carbon offset
- Sale of surplus electricity
- Sales of solid/liquid fertilizer

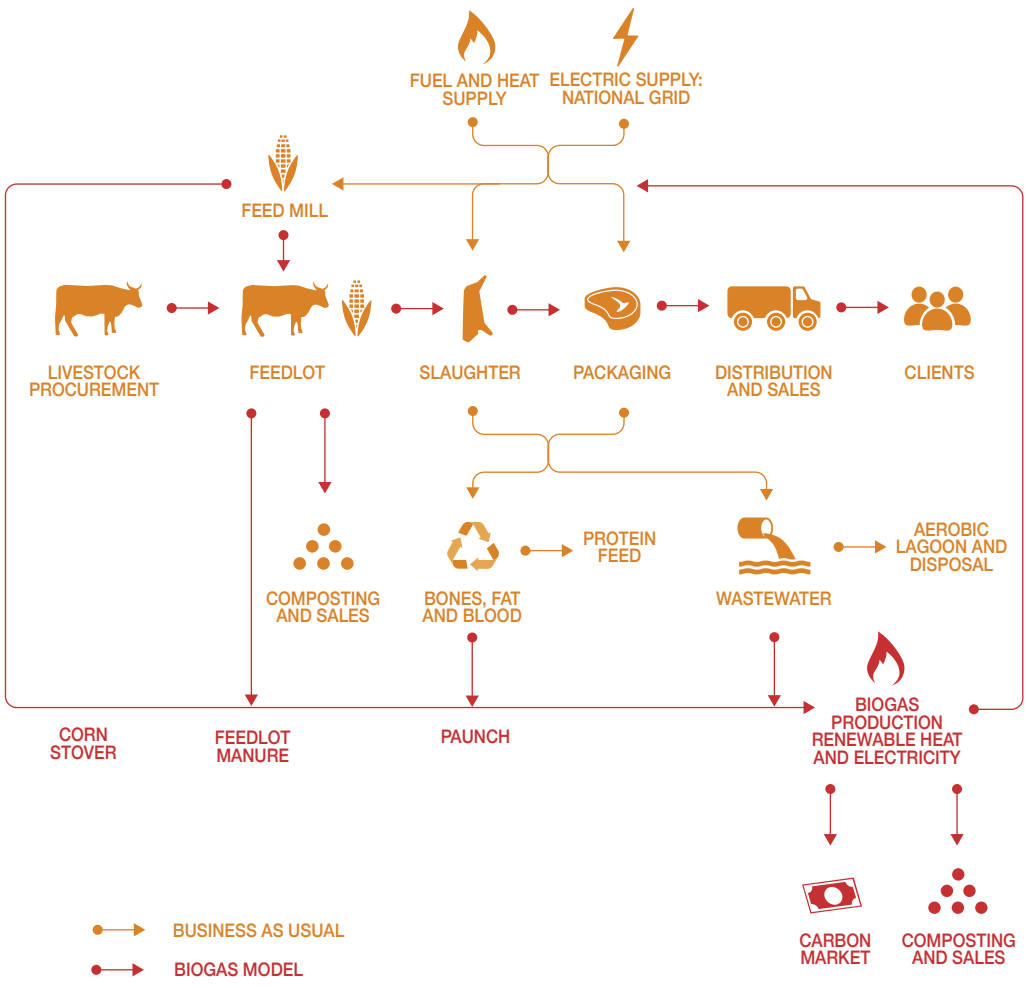
SOCIAL & ENVIRONMENTAL COSTS

- Potential leakage of methane

SOCIAL & ENVIRONMENTAL BENEFITS

- Job creation
- Reduced water, soil and air pollution
- Reduced carbon emissions
- Displacement of fossil fuel consumption (both for electricity and diesel for boilers and trucks)

FIGURE 61. SUKARNE PROCESS VALUE CHAIN, DEPICTING THE INCORPORATION OF THE BIOGAS MODEL



as the removal of subsidy on industrial diesel in 2013 in Mexico have further driven the large-scale industries such as SuKarne to adapt and develop new strategies.

Technology and processes

Slaughterhouse effluent has high Chemical Oxygen Demand (COD), high Biological Oxygen Demand (BOD) and high moisture content, which makes it well-suited to anaerobic digestion process. Slaughterhouse wastewater also contains high concentrations of suspended organic solids including pieces of fat, grease, hair, feathers, manure, grit and undigested feed which will contribute to the slowing of the process of biodegrading organic matter. The biogas potential of slaughterhouse waste is higher than animal manure and reported to be in the range of 120–160 m^3 biogas per ton of wastes.

The technology used in SuKarne's methane recovery project is a dry fermentation system including bio-digesters and a percolation tank coupled to a biogas cleaning unit and combined heat and power

(CHP) units to generate electric and thermal energy. The dry fermentation process is an anaerobic digestion technology for solid, stackable biomass and organic waste, which cannot be pumped. It is mainly based on a batch wise operation with a high dry matter content ranging from 20–50% at mesophilic temperatures. It is especially suited for application in semi-arid climates as the water consumption in the process is very low compared to conventional anaerobic digestion systems.

The biogas generated will replace the electricity bought from the national network, as well as the diesel used in boilers and trucks. The facility will consist of 900 m^3 concrete air-gas-tight chambers to manage approximately 110,000 tons of waste per year. The plants will be designed as modular solutions that are scalable according to the amount of waste that is available or energy demand. This will be the first facility of its kind in Mexico and unique worldwide in terms of feedstock characteristics, its source being a commercial cattle feedlot.

Animal waste (manure) is collected at least once every six months from the pens. Internal transport of the waste from the pens to the project site will be done in trucks carrying containers within a distance no longer than 5 km. The collected manure will be transported to the plant site to be shredded and mixed with effluents from the slaughter plant such as paunch content and wastewater to prepare an appropriate organic loading rate. Substrates such as corn stover and wood chips will be incorporated to improve material structure. Prepared substrates will be loaded into the fermentation units and digested to generate biogas. A CHP unit will be used to produce electrical and thermal energy. A biogas-cleaning unit will be incorporated before the CHP unit if necessary. Wood chips will be recovered and reutilized after the composting process.

Equipment and infrastructure required for the project:

- Dry fermentation units and components.
- Substrate mixing equipment and/or machinery.
- Biogas storage and cleaning equipment.
- Combined heat and power unit for cogeneration.
- Complementary equipment and facilities for the modular units.

Funding and financial outlook

SuKarne applied for research funding from the Mexican National Council for Science and Technology (CONACYT) and, in 2012, obtained a USD 320,000 grant for the construction and validation of a dry digestion biogas pilot plant for its Culiacan site. The investment required for the design, construction and commissioning of the large-scale biogas facility is estimated at USD 12.5 million, which will be shared between SuKarne and co-investor partner IGSA. About USD 500,000 was required to develop the mass and energy balances, feasibility study, technologies assessment and selection, pilot plant design and specialized support for the design and implementation of the chosen technology.

SuKarne's methane recovery project requires approximately USD 90,681 for operation and maintenance per annum. The revenue structure consists of savings from electricity and boiler diesel replacement from energy generation, carbon offset and sales from fertilizer. The estimated revenue potential of the plant is approximately USD 1.8 million per annum with an amortization period of 10 years. This investment is projected to result in an IRR of 14.3% with 7 years return at a discount rate of 8% (Table 20).

Note: Unit value refers to the unitary cost of every expense and income; quantity refers to the amount of supply that will be required or sold product as the technology is implemented; value is the total amount per item in US dollars; difference from business as usual (BAU) refers to the additional costs

TABLE 20. SUKARNE METHANE RECOVERY PROJECT FINANCIALS

	UNIT VALUE (USD)	QUANTITY	VALUE (USD)	DIFFERENCE BAU (USD)
Cost				
Fuel	0.54 /L	1,083,022 L/yr	584,832	–
Corn stover	49.70 /t	5,839 t/yr	290,198	48,371
CHP maintenance	0.021 /kWh	23,040,000 kWh/yr	483,840	483,840
O&M / Labor			90,681	90,681
Total				**622,892**
Saving				
Diesel	0.77 /L	701,736 L/yr	540,337	1,439,893
Electricity	0.087 /kWh	15,986,471.26 kWh/yr	–	1,390,823
Soil replacement	8.41 /t DM	23,342 t/yr	196,306	131,200
Wastewater disposal	0.25 /t	18,247 t/yr	–	4,562
Water	0.54 /t	776,783 t/yr	419,463	99,307
Total				**3,065,785**
Revenue				
Electricity	0.087 /kWh	7,053,529 kWh/yr	613,657	613,657
Compost	53.50 /t	65,702 t/yr	3,515,057	(98,058)
GHG mitigation (CERs)	10.00 /tCO_2e	132,049 t/yr	1,320,490	1,320,490
Gross margin				**4,278,982**
Payback				2.9 years
Accounting rate of return				14.3%
Capital cost			12,580,057	
Amortization period	10 years			
Interest rate	8%			

incurred by the new business model as well as savings generated, mainly from diesel, electricity and carbon credits.

Socio-economic, health and environmental impact

SuKarne's methane recovery project has high environmental benefits from reduced greenhouse gas emissions. The project ensures proper disposal of animal waste, requires less area than aerobic compost, reduces the volume and weight of landfills, produces a sanitized compost and nutrient rich liquid fertilizers, maximizes the benefits of recycling and in the process improves the air quality through improved odor and reducing groundwater contamination. It also displaces the diesel consumption in the feed mill, trucks and slaughterhouse. Additionally, the project improves the electricity burden on the regional electricity board by reducing its purchase from grid. The economic benefit from improved electricity in the region goes beyond the enterprise. In addition, SuKarne provides additional employment – nine employees for the management of biogas plant and electricity generation operations.

Scalability and replicability considerations

The key drivers for the success of this business are:

- Capital investment from administration board and co-investors.
- No barriers in accessing available in-house animal and agro-waste.

- Supportive environment for environment-friendly initiatives, with many existing livestock projects registered for CDM in Mexico; SuKarne benefits from streamlined process.
- Diesel subsidy removal.
- Favourable policies and incentives by the Government of Mexico.

SuKarne has five livestock production operations across Mexico. Based on the operational viability and profitability of its first large-scale biogas plant, SuKarne plans to separate its biogas operation into a new company and develop similar projects in all its operations across Mexico. This project has replication potential in other large livestock farms but needs to counter the challenges of adequate skilled human resources, investors that understand business risks, carbon credit markets and stable, supportive, government energy policies and financial incentives.

Summary assessment – SWOT analysis

The key strength of the project is its shorter payback period for high investment cost and strong partnership with affiliated companies (Figure 62). The weakness stems from high cost of technology that can deter its promoters from making the investment.

FIGURE 62. SUKARNE METHANE RECOVERY PROJECT SWOT ANALYSIS

	HELPFUL TO ACHIEVING THE OBJECTIVES	HARMFUL TO ACHIEVING THE OBJECTIVES
INTERNAL ORIGIN ATTRIBUTES OF THE ENTERPRISE	**STRENGTHS** ▪ Assured supply of waste ▪ Low O&M and high revenue ▪ Strong partnership with affiliated companies ▪ Natural process of dry fermentation ▪ Food security ▪ Efficient waste and water management ▪ Climate change mitigation and adaptation	**WEAKNESSES** ▪ High technology cost ▪ Requirement of high skilled labor for this technology and research and development ▪ Too much heterogeneity among the livestock production units in relation to their size and use of technology
EXTERNAL ORIGIN ATTRIBUTES OF THE ENVIRONMENT	**OPPORTUNITIES** ▪ Environment stress reduction offers carbon credit market opportunities ▪ Output from biogas plant is high value fertilizer which can be harnessed for additional revenue ▪ Electricity demand is growing and need for renewable energy-based electricity generation increasing in Mexico ▪ Recent changes in legislation on renewable energy control ▪ Classification and separation of waste, translate into increased opportunities for generation ▪ High-quality renewable fuel; biogas has several proven end-use applications ▪ Country's participation in the methane-to-market alliance	**THREATS** ▪ Possible human health risk may lead to investment needs ▪ Possible risk from leakage of gas may force O&M costs higher ▪ Delay in administrative proceedings ▪ Environmental laws are not enforced ▪ Weak national capabilities to design and manage projects to reduce methane emissions ▪ Lack of comprehensive schemes to address the issue of livestock waste ▪ Lack of co-generation equipment for all types of farm sizes and variable methane production

The business offers many opportunities for replication due to the high demand for electricity and heat sources as well as the opportunity to become a sustainable leader in meat industry by significantly reducing fossil fuel consumption, revoking the misconceptions of the livestock industry's contribution to GHG emissions and ultimately helping the future generations live in a cleaner and better world.

Contributors

Kamalesh Doshi, Simplify Energy Solutions LLC, Ashburn, Virginia, USA

References and further readings

Cepeda, J. Interview. November 14, 2012.

Clean Development Mechanism. 2011. Methane recovery and utilization from operations in beef cattle pens from SuKarne. Project Design Document 2.

López, Á. 2012. Manejo sustentable del inventario y extracción de ganado en México; Abasto de carne para el mercado nacional. 2nd Congreso Ganadero, Guadalajara, Jalisco, 2012.

Ministry of Environment and Natural Resources (SEMARNAT). 2008. Mexico profile: Animal waste management methane emissions. Methane to Markets.

Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (SAGARPA). 2007. National Livestock Program 2007–2012.

Vizcarra, D. Interview. February 1, 2013.

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.

Notes

1 IGSA: http://www.igsa.com.mx
2 German partner: http://www.bekon.eu