MEXICO

Biogas from Agaves: Residues Instead of Revelry

Agricultural waste presents a global potential for climate friendly energy production and protect the environment. Like in Mexico, where a scientist is pushing for biogas production from agave residues that come from Mezcal distilleries. This initiative is acclaimed as a good idea for global climate protection, according to the German Biogas Association, which urges the German government to initiate export promotion to tap into such potentials.

Author: Oliver Ristau

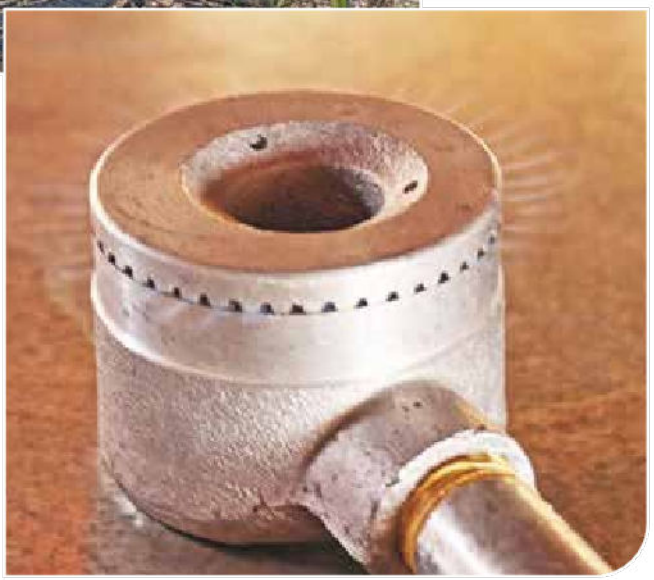
They are known as the "Gold of Oaxaca" or the "King of Matatlan" bearing colorful labels and served with salt and crushed worms: High-proof agave specialties from Mexico. More than 90 percent of the distillate, internationally known as Mezcal, originates from the state of Oaxaca and is distributed worldwide. From bars in New York to Berlin, it enjoys growing popularity among cocktail enthusiasts.

"It's better to drink it straight," recommends young Sergio, who supervises his grandfather's distillery. It is an open wooden shed along the road between the Mezcal strongholds of Tlacolula and Santiago Matatlan, where the family distills and sells their Mezcal. These small-scale operations dominate the scene, with thousands of them scattered throughout the state. Edwin Zelaya leans against the sales counter. "What do you guys do with the vinasse?," he asks the young man. He waves it off: "Oh, it's not much. We just dump it somewhere around here." And he points behind the shed, where the terrain slopes down, and to where rows of agave grow in the valley.

PHOTOS: OLIVER RISTAU

Cultivation of the agave is growing in Mexico – as shown here at the Tierra de Jagua distillery.

Sustainably oriented: Agronomist Edwin Zelaya has written his doctoral thesis on the biogas potentials of the agave plant.



Faint flame: The biogas, still rich in CO_2, burning with a faint flame in the kitchen of the Capotlan distillery

Edwin Zelaya is an agronomist and scientist from the University of Oaxaca, as well as a small business owner. "You can extract biogas from the vinasse. It's much better than dumping it into the environment. I have systems like that available. They provide energy for your kitchen and also high-quality fertilizer," he explains. The young man has never heard of this before but is immediately enthusiastic. "That's a great idea. I'll tell my grandfather about it." Vinasse is a liquid residue left after the distillation of agaves, alongside solid residues known as bagasse. While bagasse is used as construction and fuel material, there is no use for vinasse. Therefore, Zelaya investigated its potential for biogas production in his doctoral thesis two years ago. He even put it into practice not far from Sergio's wooden shed at the "Tierra de Jaguar" distillery in Tlalocula.

There, agaves grow in rows – not massive monoculture, but still impressive, as the partly towering plants stretch out into the blue sky. Just behind the agave field lies a large pit in the field, filled with a rust-colored broth. That is the vinasse. Zelaya reaches for a wooden stick and stirs it for demonstration purposes. "The pit is about two meters deep," he says.

Here, the distillery "disposes" of the waste product. Three white PVC bags, installed by the scientist to test the biogas, lie ready. They theoretically hold 6.5 cubic meters (m^3) each – 5 m^3 for the liquid and 1.5 m^3 for the gas. Right now, they are empty. The owner does not care about it. According to Zelaya, vinasse is good for nothing else but producing biogas and organic fertilizer.

Otherwise, it is a toxic brew for the environment: with a pH value of 3.5 to 4, it acidifies the soil. It also contains organic ▶

Delighted with biogas: Yolanda Santiago (left), Thania Zarate (right) from Capotlan and the Biogas installer Edwin Zelaya.

The biogas bag digester at Capotlan holds 10 m³ of liquid and 5 m³ of gas.

substances that bind oxygen when in contact with water. This means that if the vinasse enters rivers, it can be lethal for fish. In addition, the "residual alcohol" in the form of methanol and ethanol causes a severe hangover for flora and fauna.

90 Million Liters of Unused Vinasse Waste

Zelaya calculates that up to 90 million liters of the substance are produced in Oaxaca every year, far more than the approximately 6 million liters of agave schnapps that the Mexican state produces each year. So far, distilleries have been dumping most of the liquid waste into the environment somewhere. There are no regulations for disposal in Mexico. Nature has to deal with it somehow.

However, the problem is growing: Mezcal has embarked on a global success story in recent years. Demand is skyrocketing, and the liquor is almost exclusively sourced from the central Mexican state. Furthermore, even Tequila producers from northern Mexico are purchasing agaves in Oaxaca. The consequence? "More and more farmers are cultivating agaves instead of maize. It's much more profitable," reports Zelaya. This is because Mezcal is relatively expensive. Even in Mexico, a liter can hardly be purchased for less than 20 euros. The long growth period of the plants is the reason behind this. They have to be in the field for at least six years before they can be harvested.

The bottom line is that farmers can earn a significantly higher margin with agaves than with traditional foodstuffs. This could potentially reduce the food supply in the state in the future. After all, less water is required for the cultivation of agaves than for maize, for example. One thing is certain, however: The growing demand is leading to increasing amounts of waste. Scientist Zelaya wants to create an alternative to this.

Biogas Yields Comparable to Sugar Beets

As part of his dissertation, he closely examined the yields that vinasse can provide during anaerobic digestion in "Biobolsas". One notable finding is that the residual material takes days to initiate fermentation without the addition of bacteria. However, pure vinasse could yield high returns. In trial operations, they attained approximately 300 milliliters of methane per gram of substrate, he explains. This is roughly equivalent to the content found in sugar beets in our region.

To expedite the fermentation process, he mixed the vinasse with cattle manure. As a result, a blend with a 75 to 25 ratio of manure is preferable. "All the necessary bacteria for fermentation are present in the cattle's stomach," Zelaya points out. Consequently, fermentation begins immediately, allowing the facility to reach maximum yield within just two days.

The microorganisms also work to decompose the toxic substances present in the vinasse. In addition, Zelaya mixes lime into the bag fermenters to neutralize the pH level. What remains is a residue suitable for use as fertilizer, as demonstrated by the scientist with two groups of young agaves growing on "Tierra de Jaguar". One group was given the organic fertilizer, resulting in lush growth. The other had to manage without fertilizer and is less than half as robust. His doctoral thesis confirms the high nutrient content of the "Biol" fertilizer. It is rich in nitrogen, phosphorus, and potassium.

Biogas Instead of Firewood

Zelaya is convinced that biogas could provide a sustainable future for Oaxaca. That is why he has set the system up himself and established a small startup. For that, he purchases a special foil that is delivered from the capital Mexico City. From that, he makes the

Colorful pictures: Mescaleria Capotlan lies in the Mexican state of Oaxaca.

sacks that act as digesters. He buys all the other components from specialist dealers. His concept is to then install the systems at the customer's premises. Recently, he reports, he received an order for a small system from a university in another state. He packed it up and sent it by courier.

In Oaxaca, he sold and installed a facility to a distillery, located approximately a three-quarter-hour drive from the test site "Tierra de Jaguar". The road leading there passes through fields of green agave. The soil is dry in spring, with the rainy season starting in early summer. The settlements on the road to the capital, Oaxaca, with its 700,000 inhabitants, are lined with car repair shops and numerous small roadside eateries offering tacos, meat, and spicy sauces often heated with firewood. The smoke from the wood rises like a column in the air. Biogas can become an alternative to firewood, at least in places where sufficient residues are generated. This is the case at the "Capotlan" distillery, which Zelaya has now reached. The distillery aims to enhance its image as a sustainable producer, particularly to the daily influx of tourists from the USA and Europe who come for mezcal tasting. The company also relies on solar power, with a 220-kilowatt PV system installed on the roof, providing electricity for the production process.

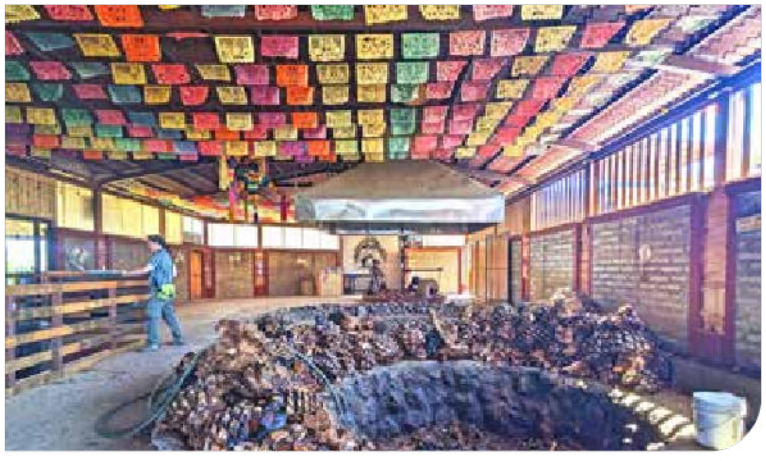
Gas Engine for Agave Mill

The biogas sack in the backyard is fully inflated, holding approximately 5 ▶

The pig farm in Oaxaca now produces biogas from slurry.

Sizzling yields: Biogas powers Capotlan's company kitchen.

Toxic mixtures: The vinasse remains at the end of the mezcal distillation process and is usually disposed of behind the field.



Before Mezcal is produced, the agaves have to be heated, hacked and crushed.

cubic meters of gas and 10 cubic meters of liquid. Currently, valuable energy is being discharged into the surrounding air because Capotlan does not utilize the gas. However, this is set to change soon, as Zelaya demonstrates on the spot with the assistance of two Capotlan employees: Thania Zarate, responsible for marketing and renewable energies, and Yolanda Santiago, who heads a reforestation program.

He opens the valve on the large biogas bag and directs the biogas through a flexible pipe to a connection in the adjacent company kitchen. Traditionally, cooking in the kitchen relies on firewood, but not today. Zelaya ignites the gas and grabs a frying pan, while the cook hands him the oil. Shortly after, two eggs sizzle in the vegetable oil. The kitchen is not the only potential application site. Processing the agaves involves a mill, currently powered by an electric motor. Production manager Pablo Ramos envisions the possible use of a gas engine in the future, utilizing their own biogas.

"Pioneers like Capotlan are crucial for the widespread adoption of biogas in the industry," says Zelaya. "Because there is no government funding available, companies must recoup the investment of €2,000 to €3,000 from their own business." However, many of the predominantly small mezcal producers are reluctant to make investments like that.

Therefore, Zelaya has turned his attention to another industry that also generates a large amount of waste: Oaxaca's cattle and pig farms. Not far from the agave distillery lies one of the two farms he has managed to persuade to adopt biogas. One of Zelaya's well-filled white biogas sacks lies right next to the pigsty, from which loud grunting can be heard. In front of it is a covered pit where the pig manure is stored.

Carlos Santiago is the foreman. He regularly lights the gas stove in the kitchen to warm up his lunch. He appreciates this because the stove generates less heat than the usual fire and produces less smoke. However, Santiago mentions that the pig farm is primarily interested in the fertilizer left over after the fermentation process. Alongside the nutrients from the pig manure, this fertilizer contains a lot of water. This is because the installation of Zelaya's Biobolsa system, for the first time, the farm is directly collecting liquid pig manure, some of which was previously disposed of in an uncontrolled way. Santiago also suggests the possibility of using gas as a source for heating the piglet nursery, although this idea has not been further specified.