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Beyond Sugarcane: Rethinking Ethanol Production in Pakistan

Visit any sugarcane field in Punjab after harvest, and you will witness farmers burning agricultural residue. In the process, potential energy becomes smoke, possibility becomes ash, and energy security becomes a dilemma that policymakers often overlook.

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Introduction

The ethanol sector in Pakistan consists of sugarcane molasses and alcohol, and this alcohol has been exported overseas. In the interim, the country imports billions of dollars' worth of fuel that it could produce domestically. The 2024 Ethanol Blending Programme is a "rare policy window" for the government. Without a feedstock policy, energy directives carry little weight.

But most policymakers have failed to recognize the large quantity of biomass waste generated in Pakistan annually. Each year, 121 million tonnes of biomass waste, such as cotton stalks, rice husks, and wheat straw, is either burned in fields or left to rot. There is plenty of potential for real change in energy; it's just that no one is looking.

It is hard to say when there will be a better time. In fact, worldwide, second-generation ethanol technologies such as cellulosic ethanol production, artificial intelligence to optimize ethanol fermentation processes, and the engineering of thermotolerant microorganisms are moving from the academic realm into practice. What Pakistan requires is institutional courage and policy boldness to integrate, localize, and industrialize these technologies, and create a smarter ethanol ecosystem.

The other barriers are not scientific, but institutional. Cellulosic ethanol has been successfully produced in pilot plants in Brazil, India, and the United States, and can be produced economically beyond the lab. The problem for Pakistan is not to develop a new technology but the adoption of the existing one, which is already available, and make it work within the local context of feedstocks and climate, as well as the local conditions of industry. The impact of this delay is felt twice in a year, first in the price of imported fuel that the nation has to pay, and then in the loss of agricultural residue that it is burning instead of turning into useful products.

"Every tonne of wheat straw burned in a Punjab field is not agricultural waste; it is unprocessed fuel, and Pakistan is letting it burn voluntarily."

Technology Overview

A mill in Punjab is waiting for the right key while wheat stalks are rotting in the fields of Sindh, and the rice husks are smoldering outside the mill, carrying fermentable sugars in a hard shell of biomass, and a biological key waiting to unlock it. New technologies developed to do this work can now be able to penetrate this biological barrier in a clean, efficient and cost-effective manner, with costs reducing year on year.

Three technologies can benefit Pakistan's ethanol sector:

Advanced Lignocellulosic Pretreatment: This involves the chemical breakdown of the hard exterior of farm waste revealing the sugars contained within the plant that can be fermented into ethanol, an energy source for Pakistani farmer's use as fuel without a second thought.



Heat-Resistant Yeast Engineering: These are special microbes which do not die or perform less well in the hot summer weather of Pakistan. They continue to produce ethanol reliably where conventional yeast would have failed.

AI-powered Fermentation Monitoring: AI can track the entire fermentation process in real-time, detect inefficiencies and failures, and optimize yield at a pace, and with an accuracy beyond the capabilities of a single human operator.

This is not something beyond our reach; it is technology that we already have but are not using, because of institutional and governmental resistance. Both the University of Agriculture Faisalabad and the University of Engineering and Technology Lahore are already exploring these areas, yet they remain under-funded and don't have links with distilleries needed to scale them up.

Not building anything new, it would just be a matter of connecting what already exists, would be a structured national programme, which would link these universities with the operating distilleries. The National Biofuel Policy did just exactly that by calling for public-private research collaborations, and matching grants for pilot-scale fermentation projects. Pakistan possesses the scientists, it has the raw material, and it has the distillation plant. What it lacks is the coordinating mechanism to make three separate assets one working industry.



Figure 1: Overview of sugarcane cultivation in ethanol production. Credit: Pexels.com



Key Findings & Impact

121 Million Tones of Biomass Going to Waste: Agricultural wastes like rice husks, wheat straw, and cotton stalks are being wasted in Pakistan every year, namely 121 Million Tones. This organic resource could be utilized efficiently, and reduce 15-20% petroleum imports, and resulting in significant cost savings for Pakistan.

Cost reduction of 40 percent is possible with cellulosic ethanol: Even if Pakistan manages to establish a small ethanol plant using crop waste, there is enough proof in the world that the cost of ethanol production per liter can significantly and sustainably drop. For Pakistan, the investment in second-generation ethanol is not an expense, but a strategic investment that can generate returns.

The Molasses Model is at End-point: In Pakistan, current ethanol factories are running at 100% capacity, and cannot make more ethanol unless they have a new raw material. The 2024 blending programme will likely achieve little, unless the supply of feedstocks is urgently increased.

Just 10% Ethanol Blending could save \$1.5 billion to \$2 billion annually: The 10% ethanol blending in the fuel supply will save Pakistan billions of dollars annually in the import cost of petroleum. This would provide great relief, equivalent to the total research investment needed for an entire industry.

The Talent is in Pakistan, but it is not connected: Pakistan has scientists, researchers, and engineers who can develop this industry. Every year, they graduate from universities and are not fully utilized. Only a national strategy is required to link these minds with the factories, farms, and governments that need them.

Combined, these five facts lead to one single conclusion: Pakistan has no energy problem, no technology problem and no talent problem. It has a coordination dilemma. The technical and scientific resources, and human capital to develop a world class second generation ethanol industry is already available within the country's boundaries. The missing piece is the policy framework to link them together, and a national ethanol roadmap with strong targets, funded at a predictable level, and with dedicated institutional structures that will create incentives for universities, distilleries, and government ministries to implement their plans at the same time.

What's Next?

There are certain challenges that Pakistan needs to address to make this vision a reality. There is no firm government blending law, low funding for university research, and scientists are not meeting with distillery owners. Most importantly, there is a critical discussion we must have about farmland being used for fuel.

Pakistan has good future opportunities. India has already demonstrated that a meaningful programme on ethanol blending is possible. Pakistan's inaction in this matter is its choice. Investments in and development of cellulosic ethanol continue to increase globally, costs continue to decline, and international development partners are looking for partners for pilot programmes for biorefineries. Pakistan's agricultural abundance, industrial infrastructure, and scientific community's overall abilities should enable it to progress at a faster pace.

The growth of the ethanol industry in Pakistan cannot be decided in the corridors of government or the chambers of sugar mills, but in a test facility somewhere in Punjab where dedicated researchers are given the funds and institutional backing that they need to conduct research. There is no need for a miracle in Pakistan. It needs a pilot plant, serious policy commitments, and one generation of scientists who make strong contributions to the ethanol sector and prove their research with evidence and data. Sugarcane was not the whole story; it was just the starting point.

The science is well established, the raw materials are plentiful, and the world is more conducive than ever to the development of projects in developing countries. So, Pakistan has to decide, and decide now; whether it is a producer or a consumer of the energy transition. This decision won't be made in one announcement of a policy.



It will be created, step by step, during each year that it becomes funded or unfunded; each year it is included in a regulatory process that allows or disallows ethanol blending, and every year the country decides to waste its agricultural residue by burning it instead of converting it.

About the Author

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