Environmental ingenuity: These creative business ideas aim to be both sustainable and successful

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Kelp has the potential to become the biofuel of the future. USC Dornsife researchers are currently testing a method designed to grow enough of the seaweed to transform the energy landscape. Credit: Dan Stiles for USC Dornsife magazine.

Picture this: Out in the open ocean, rows of farmed kelp spanning an area about the size of Mexico. Once harvested and processed, this rapid-growing seaweed would be turned into a fuel that you could pump into your car. No more relying on fossil fuels that take millions of years to form—and whose emissions into the atmosphere are the biggest contributor to the Earth's rising temperatures.

Reams of scientific evidence including a recent report from the United Nations Intergovernmental Panel on Climate Change—a nonpolitical assessment by 91 scientists from 40 countries—paints a stark picture for the economy, health and the environment if aggressive steps to reign in global warming are not taken in the next decade.

To tackle the challenge, USC Dornsife researchers have been testing creative solutions, from kelp biofuel to entirely new energy economies to redesigning waste. These solutions can be both entrepreneurial and profitable, creating innovative business models that can fuel jobs and a healthy economy while also saving the planet.

Plant Power

At the USC Wrigley Institute for Environmental Studies' Marine Science Center on Santa Catalina Island off the coast of Los Angeles, researchers are testing whether kelp could become a renewable fuel.

Why kelp? Diane Kim, associate director for special projects at the institute, is part of the team heading up the biofuel research.

She says that the common giant kelp found along the coast of California is one of the fastest growing organisms on the planet. Requiring a minimum of natural resources, it can grow one to two feet per day under ideal conditions.

"Kelp is often referred to as a 'sequoia of the sea' because it can get so massive—up to 100 to 150 feet in length," she said. "And these organisms start out not much larger than a bacterium."

To grow, kelp requires sunlight and nutrients. Both are plentiful in the ocean, but there's a hitch.

"Light is up near the surface and nutrients are found deeper in the water column," Kim explains. Along California's coast, upwelling brings that water to the surface, which is why such large kelp forests are found near the shoreline. But that's not the case in the open ocean, where kelp has the potential to be grown on a much larger scale.

"This has the potential to transform the energy landscape as we know it," said Kim.

With funding from the U.S. Department of Energy's Advanced Research Projects Agency on Energy, USC Wrigley Institute researchers, aided by an industry partner, are testing a depth-cycling strategy using a pilot-scale system nicknamed the "kelp elevator"—a structure in the ocean that moves kelp up and down, taking it to the surface to absorb sunlight, then back down to the nutrient-rich depths.

If successful, this system could be the basis for an autonomous network of floating kelp farms that could be scaled up to produce the amount of kelp biomass necessary to make macroalgae biofuel cost competitive with fossil fuel.

Over the next year or so, the team, which includes Kim, John Heidelberg, associate professor of biological sciences and environmental studies, David Ginsburg, associate professor (teaching) of environmental studies, and many undergraduate and graduate students, will test different depth-cycling strategies and varying species of macroalgae for optimal growth.

Once they can demonstrate kelp growth under those parameters, their industry partner, Marine BioEnergy, will start commercialization. Chemical engineers at the Department of Energy's Pacific Northwest National Laboratory are refining a process to turn the kelp into biofuel on a large scale through a process called hydrothermal liquefaction. The output, they anticipate, will be nearly carbon neutral.

Preliminary calculations suggest that if their concept works, kelp biofuel has the potential to meet the needs of all U.S. transportation fuel.

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A New Energy Economy

The USC Wrigley Institute's kelp biofuel project continues a legacy of energy research at USC Dornsife that stretches back decades.

Enter the office of G. K. Surya Prakash, director of USC Dornsife's Loker Hydrocarbon Research Institute, and you'll find clues that a brilliant and prolific scientist dwells within.

A bookcase lined with organic chemistry textbooks from years teaching fundamentals to undergraduates stretches along his desk, which is covered in neat piles of scientific papers nearly 2 feet high.

And if you look closely, you'll find a series of curious instruments that reveal his life's work: a palm-sized plastic propeller attached to a fuel cell that runs on methanol; a dinnerplate-sized cook stove, also fueled by methanol; and a small glass bottle filled with what looks like powder laundry detergent.

A natural byproduct of the biodiesel industry is getting a second life. USC Dornsife researchers have invented a way to turn glycerin into a valuable natural preservative and antimicrobial agent that can be used to make cosmetics and soaps. Credit: University of Southern California

Holding up the bottle, Prakash, George A. and Judith A. Olah Nobel Laureate Chair in Hydrocarbon Chemistry and professor of chemistry at USC Dornsife, explains that the unassuming white granules are a new product using technology developed at the institute to help large buildings manage their air quality more efficiently.

The particles, fabricated for commercial use by the company enVerid with a license from a Loker patent, absorb and capture carbon dioxide and other air contaminants.

"Think of any large building," Prakash says. "Thousands of people are breathing in oxygen and exhaling carbon dioxide."

If carbon dioxide levels rise too high, people will get dizzy or sleepy. So typically, building ventilation systems will cycle in air from the outside every couple of hours to clear out carbon dioxide and other contaminants. That process uses a great deal of energy, Prakash explains. But when the granules are put into the HVAC system, it absorbs air impurities and reduces a building's energy use by 20 to 30 percent.

"It's a way to offset carbon dioxide that's twofold," he says; Reduce the amount of carbon dioxide in a building's air circulation while also reducing the carbon footprint of energy used to manage the air quality.

Prakash has spent four decades at USC Dornsife thinking about energy—ways to store it and ways to harness it. Those instruments in his office illustrate some of the practical uses of what's known as the methanol economy, the visionary concept for creating renewable energy sources he originally developed with the late USC Dornsife Professor of Chemistry George Olah, a Nobel laureate and Prakash's former colleague and mentor.

The starting point is carbon dioxide—a naturally occurring gas that is rapidly increasing in our atmosphere primarily due to human activities such as burning fossil fuels and deforestation. The methanol economy, a model by which chemistry is used to produce methanol in place of fossil fuels for energy storage, fuel and feedstocks, seeks to use carbon as a solution.

"Earth does not have an energy problem," said Prakash. "What it has is an energy storage and an energy carrier problem.

"The idea is that we're going to take carbon dioxide and convert it back to some chemical fuels and feedstocks using the sun's energy," Prakash said.

Methanol is easily created in a lab, and at relatively low cost, he adds. The infrastructure already exists to put it into use as a fuel and a feedstock to replace petroleum-based products.

The United States has been slow to adopt the technology, mainly because oil companies don't have much of a financial incentive to switch to the cleaner burning alternative. However, countries like China, Iceland, Israel and Sweden have adopted the renewable fuel source for various uses, mainly for transportation. (A renewable methanol production plant operated by Carbon Recycling International in Reykjavik, Iceland, bears Olah's name.)

India is also considering how to incorporate methanol as a transportation fuel as well as a cooking gas to replace widely used kerosene, which produces dangerous pollutants—hence the prototype of a methanol-fueled stove on Prakash's desk.

A Winning Catalyst for Change

Zhiyao Lu is a postdoctoral scholar at the Loker Hydrocarbon Research Institute. Prior to earning his Ph.D. in chemistry from USC Dornsife in 2016, he was studying pharmaceutical sciences. But his interests began to shift. Around 2010, he began seeing reports showing that, as the biodiesel industry expanded and vegetable oil was being used on a larger scale, crude glycerin was being produced in rising quantities.

"More and more of it was ending up as waste or as a pollutant," Lu said. "I realized it was a problem, and I set this goal for myself to provide at least one solution to make the situation better."

He set his sights on finding a way to turn the waste material into something valuable. Working with USC Dornsife Professor of Chemistry Travis Williams, he developed a catalyst that enables an exceptionally efficient chemical transformation that converts glycerin into lactate. Usually derived from plants, lactate is a valuable natural preservative and antimicrobial agent with a wide range of applications. Most often it is used in cosmetics and soaps.

Lu was interested in commercializing their findings. Williams encouraged him to pursue support to translate their research. So, Lu applied for the 2018 USC Wrigley Sustainability Prize, which was created by the USC Wrigley Institute to inspire and support the development of entrepreneurial businesses focused on improving the environment. He took home first place along with $7,000 to help get the business off the ground.

On the heels of that honor, Lu was selected to participate in the National Science Foundation Innovation Corps (I-Corps) program, a seven-week curriculum that supports scientists in bringing their technology to market. Through I-Corps, Lu and Williams met with potential customers, partners and investors to learn the next steps that would take their technology from the lab to a commercial enterprise.

As a result, the pair's company, Catapower, will be working with World Energy, a top supplier of biodiesel in the U.S., to co-develop the chemical process into a commercial one. Right now, they are building a demonstration of how that would work in their manufacturing plants.

Lu explains that with just a few extra steps and some additional staff, glycerin can easily be converted to lactate as part of each plant's day-to-day operations, using existing equipment.

By Lu's calculations, Catapower's process could lower the overall cost of producing lactate by 60 percent, when compared with the current commercial practice used to manufacture it.

"Our business advisor said once we start producing it, it will be like printing money," Lu said. "I'm not as optimistic, but I think the profit margin is good enough for us to run a sustainable business."

Provided by University of Southern California

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