

A COLLECTION OF STORIES ABOUT THE OPIOID CRISIS, CLIMATE CHANGE, AND
THE PEOPLE WORKING TO FIX THEM

by

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Abstract

The opioid crisis touches millions. Many families, including my own, have been affected by addiction to opioids. The first half of this collection of stories examines how addiction works in the brain, naloxone distribution, and medication assisted treatment. The second half focuses on climate change, a problem that will affect all living creatures over the next several decades. These stories look at the health of pollinators, air pollution, wind power, and carbon emissions from marine shipping. In both parts of this thesis, people from various backgrounds work passionately to solve these two important problems facing humans in the future. These two stories also illustrate the inevitable human flaw of simultaneously inventing new technologies and medicines while failing to predict their negative consequences. Eventually, people must repair these human-caused problems.

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Introduction

The items in this collection were created from 2019 to 2022 in the Johns Hopkins Master of Arts in Science Writing program. This thesis collection comes in two parts.

The first, focusing on opioid use disorder, can be linked to Purdue Pharma, the company that marketed the time-release drug OxyContin as a nonaddictive pain reliever. The company misconstrued the true effects of the drug and even misled doctors and patients to encourage prescribing habits. While Purdue insisted that the time-release system made it impossible to abuse, many patients still became addicted to the drug. Some even died of overdoses. Then it became worse. The truth that it was a strong opioid with potential for abuse and addiction was revealed, and regulating bodies began discouraging and limiting the prescription of opioids for chronic pain. Chronic pain patients looked to the streets. Many of them found pills dealt on the streets, but some turned to something cheaper—heroin. In recent years, the epidemic has worsened further with drug dealers adding fentanyl to their product, making their drugs both stronger and more addictive. This substance, which is 50 times stronger than heroin, can prove lethal to drug users.

The second theme of this collection, the environmental and ecological challenges posed by climate change, links back to the 1880s when the then innovative idea to use coal to power homes and factories entered the scene. Today, fossil fuels are the primary source of electricity today. In the 1970s, Exxon learned that this technology was causing human-induced climate change. Like Purdue Pharma, oil and coal companies, politicians, and lobbyists tried to cast doubt on the scientific consensus that humans were causing climate change. Recently, reports show that these companies have also attempted to cast themselves as pro-environment by touting

things like carbon capture facilities, which, in reality, save only a miniscule amount of carbon, as a disguise for the work they are doing to counteract true environmentalism.

Still, in both opioid use disorder and climate change, people can find solutions. As humans, sometimes we need to stop, take a breath, and look at the damage being done. While OxyContin provided some chronic pain patients relief, it also caused devastating addictions and increased overdose deaths. Although fossil fuels transformed the economy and spurred industrialization and modern agriculture, they also caused anthropogenic global warming. Scientists and advocates alike are studying ways to improve the lives of countless individuals, for example, by touting medication-assisted treatment for opioid use disorder, or by combining clean energy and biodiversity efforts in solar-pollinator sites. These are two very different fields, one closer to medicine and pharmacy and the other, ecology and environmental science, but they are both issues that touch the lives of many. And while these researchers toil away searching for solutions, the rest of us should stay vigilant to make sure we are not causing more problems than we started with.

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Chasing the Dragon: How Opioid Addiction Starts

Throughout my high school years, my sister had been to rehab countless times. She was two years older than me, but we weren't that close as teenagers. It made me sad. She seemed to be more interested in partying with her drug-dealer boyfriend at the time than making it home for family dinner.

In 2011, I went to live in a college dormitory that was about a 45-minute drive from my home. On the cusp of summer and fall, one of the only times it is enjoyable to be outside in Chicago, my mom met me on campus to picnic by Lake Michigan. Sitting on a blanket, my mother smiled and said she had to tell me something. It was about Molly. I anticipated bad news and wondered why she was smiling at all. "Molly...she's doing...heroin," she said, eyes wide and mouth no longer curled upwards. My heart felt as if it was a 20-pound dumbbell dropping to my stomach. How could my sister, the sweet, brown-eyed girl I played dress-up with growing up, be involved with something like this?

But I would come to learn that she was far from alone. In 2019, an estimated 10.1 million people aged 12 or older misused opioids in the year prior, according to the U.S. Department of Health and Human Services. Like it was for me, people may have a difficult time understanding why someone would keep doing a drug that has the potential not only to destroy their lives but to kill them. Upon further investigation, I learned that this urge to continue using opioids relates mainly to the brain's reward system and three key factors: tolerance, withdrawal, and cravings.

The first time you use an opioid, the brain releases dopamine, a feel-good neurotransmitter. It's like when you win the jackpot on a slot machine. You feel a peak of pleasure. You want to feel that good again, so you take the opioid once more for another dose of

dopamine. You play one more time, but you don't win as much. You think, hey, at least I'm still making it out on top.

Now let's say you continue playing the slot machine, and you keep winning a little bit less every time. The first, second, third time, you might be slightly disappointed. But after the tenth try, you're losing all your winnings. You decide to leave the machine and move to the poker table.

In the same way, after repeated opioid use, your brain starts to become less responsive to the same dose of the drug. You need more of it to release the same amount of dopamine that you're after. This is what medical professionals call tolerance.

Dopamine is not the only culprit. Once you start using opioids, a whole bunch of other chemicals in the body begin ganging up on you, like a group of teenaged bullies teasing the vulnerable kid. When you take an opioid, your body releases less of a neurotransmitter called noradrenaline (NA), a neurotransmitter that, when released at normal levels, is meant to keep you awake, alert, and breathing. Opioids suppress the release of NA, causing the hallmark signs of opioid use: drowsiness, low blood pressure, and slowed breathing. But with repeated use, the body starts to compensate for the suppression of NA by producing more of it. Now, you have an excess of this alertness chemical taunting you.

When you use an opioid, you are evening out these levels, and you physically need the drug to feel "normal." When you don't have any of the drug, your brain is firing excess NA chemical signals that make you anxious, jittery, achy, and physically ill. This is what is called withdrawal. Returning to opioids after building a tolerance and experiencing withdrawal is like having a gambling addict return to the casino after they lose their entire paycheck. Even though

it hurts them, financially, emotionally, physically, relationally, and even spiritually, the object of their addiction is fulfilling a desperate need for more.

After repeated opioid use, the brain starts releasing less dopamine for normally pleasurable activities, such as eating or sex. Activities the person used to enjoy now don't even make waves. Furthermore, people frequently return to opioids, even after sustained periods of recovery, when they feel high levels of stress. The probable reason for this is that opioids trigger the release of cortisol, the stress hormone, so when you experience high stress and cortisol levels rise, you want to seek refuge in the familiar calming-effect of opioids. This is a craving. People, places, and things that remind you of your drug use also trigger cravings. It takes daily, hourly, or sometimes even moment-by-moment work to stay clean.

Nevertheless, things can be done to combat the opioid crisis in the U.S., such as distributing naloxone (also known as the opioid overdose antidote), reducing stigma around and barriers to medication assisted treatment, and providing no-cost or low-cost community support services. One of these barriers is stigma. People say taking a daily medication like buprenorphine is trading one addiction for another, when, in fact, it's the most effective medical treatment out there. In addition, doctors need a waiver to prescribe these meds, which prevents some emergency room doctors from doing so if someone comes in from an overdose. Also, there's the cost issue—can someone afford to take a daily medication? Are they employed and, thus, insured? There is also the question of whether there are enough beds available in a local treatment center, and how much that will cost for the individual or family, which depends on their insurance coverage.

The first step though is to understand substance dependence. For me, it was natural to enter a state of denial when I first found out that my sister was using heroin. But, looking back,

the signs were there. She started with lesser drugs, like alcohol and marijuana, and moved onto harder stuff, such as painkillers. Knowing that opioids cause both physiological pleasure, pain, and ultimately dependence helps me understand why she was addicted. Opioid addiction does not discriminate. It affects people of all races, religions, socioeconomic classes, genders, and ages. It infected my family, too.

One of the habits of highly effective people is this: seek first to understand, then to be understood. Apart from having conversations with those who have experienced opioid addiction, learning about the science of addiction is the closest thing to understanding how addiction starts that I have found. Often addiction also stems from personal trauma that people try to fix by self-medicating. As a society, we must understand and have compassion for this. We must understand that addiction is not weakness, and it can happen to anyone. Then, we can start to write policies that benefit vulnerable people, because everyone is worthy of dignity, respect, and hope—even “drug addicts.”

A Game of Chase

It's a familiar game. You are in a swimming pool with your friend. You both decide to hold your breath underwater and see who can hold their breath the longest. You start counting the seconds. 1, 2, 3, 4, 5...10, 11, 12, 13...20, 21—okay, you can't hold your breath for one second longer. You come up for air, gasping and gulping in your first breath of oxygen in what felt like far too long.

When people are addicted to opioids, going without them feels sort of like being without air. For someone dependent on the drug, using again feels like coming up for air—doing what they need to do to survive. In fact, I used to think that opioid cravings would be like trying to quit sugar. I have an enormous sweet-tooth. But it's more than that. Much more. When people are addicted to opioids and quit, it's not like resisting that after-dinner bowl of ice cream. They are drowning. The options to eliminate the discomfort by coming up for air involve either taking more drugs, or if you have the means and desire, seeking help from doctors, who may be able to provide you with medication-assisted treatment. But not having the drugs or the help is like not being able to breathe.

This sensation has affected so many lives that it is now a phenomenon: *the opioid epidemic*, which came in three waves. In the first wave in the 1990s, people saw OxyContin advertisements claiming it was a nonaddictive painkiller alternative. But our country's fascination with and dependence on opioids started even before then. In the early 1900s, Bayer advertised heroin in its cough medicine for children. During the Vietnam War, almost 50 percent

of enlisted men in the Army serving in Vietnam experimented with either heroin or opium. Twenty percent became addicted.

But something was different about the 1990s. Purdue Pharma used questionable marketing tactics to entice doctors to prescribe the drug. They wined and dined doctors. They crafted a narrative that included pain as the “fifth vital sign.” They even aired an advertisement for OxyContin that was closer to a public service announcement for pain treatment than a drug advertisement.

Many doctors who prescribed OxyContin did so with good intentions, believing that the time-release system prevented dependence and addiction. Other unethical “pill mill” clinics overprescribed the medication to anyone who would stand in line. Even patients with true pain disorders developed addictions. Some even died of overdoses.

When the Centers for Disease Control and Prevention learned this information, they began discouraging doctors from prescribing opioids for chronic pain. Then, the second wave hit roughly around 2010. People, who sought painkillers on the streets, quickly found the cheaper alternative: heroin. Heroin overdoses skyrocketed.

A few years later, the third wave ushered in a greater danger. Fentanyl, an opioid that is up to 100 times stronger than morphine, may be easily ordered on the Internet. Drug dealers purchase this and pill presses. They press fentanyl into pills that look like their familiar FDA-approved counterparts. The lethal fentanyl seeps into the supply of counterfeit pills sold on the streets and on the Internet, and it kills people.

Still, we have a treatment for opioid addiction that works. We have pharmacological treatments, such as methadone and buprenorphine, that act on similar brain structures as opioids. By eliminating that drowning sensation, medications like these have a protective or normalizing

effect, which is extremely effective in combination with cognitive behavioral therapy. We also have naloxone, the opioid reversal antidote, that can reverse the effects of an overdose.

All things considered, we've discovered ways to treat opioid dependence and ways to ease pain without opioids, like cognitive behavioral therapy, physical or manual therapy, acupuncture, nutraceuticals, and nonopioid drug regimens. The key is to keep people alive long enough to discover that there is a way out of the water. They don't have to keep drowning. There's always a path to land.

A Lifesaver

Published in The Xylom with the title “Chicago Health Advocates Flood the Streets with Opioid Antidotes”

It was a summer morning like most other normal mornings in Chicago; people stopping for coffee, rushing to get to work on time, catching the crowded “L,” searching for empty seats, and dealers selling heroin. After one such exchange, a young man named Nick injected the drug with his friend in the passenger seat of his Honda. It took one shot, and Nick immediately lost consciousness, body slumped, breathing stopped — and his friend knew. He was overdosing. He was going to die. He had just minutes before he would be brain dead.

Nick’s friend opened the glove box of his car and pulled out another drug. This one could save Nick’s life. He injected the opioid overdose antidote into Nick’s outer thigh. Nothing. He was still unconscious. He tried again. Another dose of naloxone—and this one worked. Nick sat up straight and began sweating like he was just woken up from a ghoulish nightmare.

Naloxone, also known as Narcan, quickly reverses an opioid overdose by attaching to opioid receptors and effectively reversing and blocking the effects of other opioids. Nick, my brother-in-law, is clean and sober now, thanks, in part, to naloxone. My sister, who also suffered from substance use disorder, is clean, too. I’ve seen her heart break as her friends passed away from the disease of addiction. I’ve seen with my own eyes the way addiction can ravage families. But I’ve also seen how people with addictions can recover and lead productive lives.

Nick considers himself lucky. The Centers for Disease Control and Prevention report that more than 70,000 Americans died from drug overdoses in 2019. And, in 71 percent of those deaths, opioids were involved. Such overdoses surged in the US during the pandemic: more than

96,700 Americans died from drug overdoses in a 12-month period from April 2020 to March 2021, 72 percent opioid-related. It's clear that opioid use disorder is far from going away, and we need to think big picture to find solutions.

One solution is to have people knowledgeable about substance use disorder on the street ready to act. The woman who provided Nick with his lifesaving dose of naloxone, Laura Fry, spends her days educating people about substance use disorder and training folks on how to use naloxone. "I always tell people: you've got to have a heartbeat to do anything," said Fry, whose son recovered from heroin use disorder. She leads a Chicago-area harm reduction agency called Live4Lali, named after a boy who died from an opioid overdose. "The biggest hurdle we face is stigma."

In 2015, the Illinois Legislature passed Lali's Law requiring law enforcement officers to be trained on how to use opioid antagonists such as naloxone and first responders, including all ambulances, to carry them at all times. By 2018, all Chicago Fire Department vehicles became equipped with Narcan, and by 2019, almost three-quarters of Illinois Police Chiefs surveyed reported that all of their officers bring naloxone with them while on duty. This mindset change from punitive to therapeutic or rehabilitative measures forges a path to finding solutions, according to advocates like Fry.

"The way we use naloxone may be changing—higher doses administered more quickly," said Dr. Beth Dunlap, an addiction specialist in the Chicago area and an assistant professor of family and community medicine in the Northwestern Feinberg School of Medicine. One source claimed to know of cases where seven or eight doses were required. The right people are starting to notice, too. This is apparent with the recent news of FDA approval of a higher dose naloxone nasal spray. If the dose is high enough still remains to be seen.

So why do people, Nick included, need more than one dose of naloxone? Nick's drugs were never tested, so the drug potency and type remain unknown, but one possibility weighs heavy on my mind. A big problem has taken hold in the U.S.: Dealers get their hands on pill presses, or machines that shape powders into tablets, and they can put whatever they want in these pills, including fentanyl, a colorless, tasteless, and odorless synthetic opioid that is 50 times stronger than heroin. Even other drugs, like cocaine, heroin, and LSD, contain fentanyl. Dealers will do this so that the drugs are not only stronger but also more addictive. It's possible that Nick's drugs contained some amount of fentanyl, making it more potent, and thus more deadly, than expected.

Fry noticed this trend taking effect in the Chicago area. So now, she distributes fentanyl test strips. When people purchase drugs on the street, the origins are unknown. If people will use a drug anyway, they should at least test for an agent like fentanyl that can prove lethal.

In meeting people where they are, Fry and her colleagues give people tools to reduce overdoses out in the community. They provide tools, like fentanyl test strips and naloxone, free of charge. They also provide transportation to treatment centers and community support groups for free. This is important because the opioid crisis affects all Americans: While Black Illinois residents' opioid overdose death rate is twice that of white residents, in the United States as a whole, non-Hispanic white Americans are the most likely to die of an opioid overdose. Furthermore, people living below the poverty line are more likely to die of an opioid overdose than their affluent counterparts, according to a 2020 study. To add to the problem, the risk of opioid overdose increases for people without health insurance. This means the poor and uninsured face the greatest risk. At the same time, they face the greatest obstacles. As of January 2022, the average price of a single box containing two one-time-use nasal sprays is \$72.99. For

comparison, that is about seven to eight hours of work for someone making minimum wage in Illinois. Some 30-day residential treatment center stays can cost in the tens of thousands of dollars. For an uninsured person, this may be impossible to afford.

In addition to cost barriers, education needs to spread about naloxone. Some don't know they can go into a pharmacy and retrieve naloxone. Even some pharmacy staff members don't always know the laws and regulations in their state, according to Fry. "I've had people turned away from the pharmacy," Fry said.

Advocates agree: To unlock naloxone's lifesaving potential means making it accessible. One way to build upon the work of groups like Live4Lali, which try to lessen the burden on the groups at greatest risk, is to change policy; for example, pharmacists must give people naloxone who pick up their opioid prescriptions. Lowering costs, increasing access, and educating people about naloxone laws in their state will save lives.

Bioethicist Travis Rieder is the director of Johns Hopkins University's Master of Bioethics program and the author of *In Pain: A Bioethicist's Personal Struggle with Opioids*. He himself became dependent on opioids after sustaining serious injuries in an accident. He was able to overcome his dependency even in a medical system that is vastly underprepared for getting people off an opioid regimen. Rieder now applies what he knows to people with substance use disorder.

He touts the harm reduction philosophy of groups like Live4Lali: "Basically, it requires that we meet people where they are, recognizing that they are agents with dignity, worthy of respect, despite their choices and values," he said. "People don't deserve respect because and only if they act in accordance with our own values; they deserve respect because they are people."

During the pandemic, I have seen my family fewer times than I would have liked. Still, we all met one night for dinner the first week of the New Year. My sister is close to graduating with a bachelor's degree in finance from DePaul University. She is overjoyed to be starting a banking internship in the summer. My brother-in-law Nick is studying to be an electrician. He's optimistic about the future. They live with their Yorkshire terrier, Rocco, in a Chicago suburb. When Nick looks back on his experiences, he expresses gratitude for the people who fought for his recovery. "I would not be alive today without them."

I am grateful, too.

We Have a Treatment that Works. It Should Be Embraced

Nick Ryan died from a heroin overdose at the age of 20. He had been placed in drug treatment centers half a dozen times. But instead of improving, he made more drug contacts in the all-day group therapy sessions. The thing about addiction is that it affects the whole family. His father, Tim, also a heroin addict, went to prison for drug-related crimes and aggravated DUI.

Following the death of his son, Tim Ryan changed. He started A Man in Recovery Foundation, where he provides community support group and drug rehabilitation services to people with drug addictions. Since his release from incarceration in 2013, he has been involved with more than 1,500 interventions.

But even someone as well-versed in the language of recovery as Tim still struggles with the stigma of medication-assisted treatment (MAT), which involves a daily medication to help curb opioid cravings. Tim explained to me that addicts are in danger of trading one addiction for another. They have to want to change, and they have to take medications in combination with therapy. Some more extreme rehabilitation centers take it a few steps further—they forbid any kind of mind-altering substances, including the most beneficial treatment for opioid use disorder (OUD), buprenorphine.

OUD is a chronic medical condition with a genetic component, comparable in many ways to diabetes, according to Dr. Beth Dunlap, an addiction specialist in Chicago. Like diabetes, OUD can require a lifetime of medical treatment. But there's one key difference. People with diabetes aren't judged or criticized for taking insulin. Today, more than ever before, there are treatments for OUD that can work. The first step is to make these medications as available as possible to those

who need them. The second, interrelated step is to reduce the stigma surrounding taking a lifesaving drug such as buprenorphine.

Like Tim's son, my sister was also placed in drug rehabilitation centers on numerous occasions. She would go to inpatient treatment, and a couple of months later, it seemed like her addiction was worse. Her friend group changed, morphing into mostly unfamiliar, sketchy characters. She stopped eating dinner with the family. When she did come home, she was withdrawing, so I did not enjoy her company in the way I hoped for.

My sister was able to turn her life around. Now, she is finishing a degree in finance. She has a banking internship this summer. She recently married the love of her life, and they have a scruffy Yorkshire terrier named Rocco and a condo in the suburbs together. The positive life change began with a prescription for buprenorphine from a reliable doctor. Her significant other committed to the same journey, albeit a little slower than her. She still attends weekly support groups and checks in with her doctor frequently. I believe that MAT saved her life.

As Dr. Dunlap says, our treatments for OUD are effective, but we need to figure out how to "deliver these lifesaving treatments in a way that is trauma-informed." Sometimes trauma haunts a person, even if it happens a long time ago in childhood or adolescence. People often decide to self-medicate with drugs. Then addictions themselves are additional sources of trauma. Some of Dr. Dunlap's patients have witnessed friends die of overdoses. Many have been through more dark life events than the average person can imagine. A medical yet empathic approach to caregiving will save lives. Dr. Dunlap says of medication-assisted treatment: "the medical evidence of efficacy is extremely robust. People don't die of overdoses as much. They have healthier pregnancies. They're less likely to get hepatitis C." According to current research, buprenorphine,

the same medication that worked for my sister, significantly reduces cravings during withdrawal from opioids. MAT is accepted by many medical providers for its safety and efficacy.

However, hurdles exist. Dr. Dunlap explains that many people don't understand that some patients will require buprenorphine for long periods of time, in some cases for the rest of their lives. Hospital staff can be too hasty in releasing drug overdose patients. If you have a heart attack, for example, doctors will monitor you for a few days. The same protocol doesn't always exist for overdose patients, but it should. Another hurdle: ER doctors are sometimes reluctant to prescribe buprenorphine because of the waiver requirement—doctors need special dispensation to prescribe the drug. In some cases, physicians in the ER do not know if they can get another doctor with a waiver to prescribe buprenorphine. They may not give the patient the medication at all.

Patients who do begin treatment with buprenorphine may also feel frustrated by the need for long-term treatment. A structured plan, Dr. Dunlap says, usually involves three to four steps:

- Step One: Detox. This removes the drugs from your system, but detox is not treatment. Detox merely takes you to the next step.
- Step Two: Enrollment in an inpatient treatment center, which should span at least 90 days. Here, you retrain the brain to not need a drug to survive.
- Step Three/Four: Outpatient care and sometimes a sober living home. This step is transitional, so the patient still receives care and structure but can start to rebuild (volunteer, apply for jobs, work).

Patients and their families often struggle to find the right treatment center or sober living home. Some facilities are too far away from the home. Some are too expensive. Still others do not accept people on MAT, stemming from that thought that patients are trading one addiction for another.

A lot of people with addictions also face mental illness, as Tim realized with his son. Substance use disorder usually coexists with one or more underlying mental illnesses. These may include bipolar disorder, depression, or schizophrenia. Doctors observe and talk to patients during treatment to diagnose these underlying conditions. Cognitive behavioral therapy, which involves reframing thoughts to change behaviors, can be very effective in combination with a daily medication. It forces you to examine your thoughts. For example, if you think, “I’m worthless,” you change the thought pattern in your head by telling yourself, “I’m worthy of love.” In this form of therapy, if you change your thoughts, your feelings and behaviors will follow.

People who come to use and abuse opioids often have experienced physical, emotional, or sexual trauma prior to the addiction. Additional trauma follows as they descend deeper into addiction — perhaps breaking the law, seeing friends die, or betraying the trust of their loved ones. Gabor Mate, MD, who worked in family medicine for 20 years followed by in Vancouver’s downtown east side with people suffering from addiction and mental illness, explains it well: “When I work with addictions, the first question is always, not why the addiction, but why the pain.” Addiction starts with pain, develops with drug use to treat the pain, and leads to more pain. Individual and group therapy can help teach the patient healthy coping skills so that he or she doesn’t have to use drugs to deal with the trauma.

As Dr. Dunlap noted, we need to deliver effective treatment in a way that is trauma-informed: We must help people with understanding and empathy, rather than judgment and skepticism. Success will come as we witness the long-term benefits of these treatments. If a medication is not within the patient’s value system, we must work to understand why and respond with empathy.

Travis Rieder, PhD, a bioethicist at Johns Hopkins University, experienced opioid dependence himself and supports a harm-reduction approach to OUD, which is basically making it our mission to keep drug users alive at all costs. My philosophy is similar, but I have a slightly modified approach. If someone's not ready for treatment, I think it is our job as human beings to keep them alive until they are. When they are ready, we need to be ready, too. Harm reduction tactics include providing naloxone, the opioid overdose reversal antidote; fentanyl test strips; and clean needles.

As a family member, I also sought help. In my own years of cognitive behavioral therapy sessions, I learned that I cannot control others. What I can do is be ready to offer the best help I know how. I cannot force anyone to receive treatment, but I can be supportive of their ultimate decision to do so. We, as caregivers, must set aside our biases and speculations and, when the situation demands, deliver treatments that work — treatments such as buprenorphine. Other addictions, such as cocaine addiction, don't have as many effective treatments, but here we have one for OUD that works. It should be embraced.

52 Stories High: An Audio Script

A version of this story was published as a journalistic article on wired.com.

Jennifer: The view from the 47th floor lounge takes in the skyline, the light cobalt blue sky, and Lake Michigan. [ambient sound from the lounge] As I gaze out the window and sip a steaming cup of coffee, I don't yet realize that just five floors above my head is something truly amazing...

On the roof of AMA Plaza there are three wooden structures that in another setting might look like unfinished filing cabinets...But inside of these wooden structures, you won't find files...Instead, you will find tens of thousands of honeybees...

That's right. Honeybees. The building management company Beacon Capital Partners keeps rooftop honeybees at their buildings across the country...which is great! People love honeybees. They are important to pollinating crops and gardens...and they are most beloved for making honey and wax products.

But you might be wondering...could bees really survive at an elevation of 695 feet in the Windy City? What about the winds? What about the cold weather? And is this program making a difference? I was going to find out...

It turns out that there are actually advantages to keeping bees on Chicago rooftops...Quite a lot of them...

Corky: I'm Corky Schnadt. I'm president of the Illinois State Beekeepers Association.

The advantages to having bees on a rooftop are many. One, they're above traffic level,

Jennifer: They don't get hit by cars as much.

Corky: There's an awful lot of budding trees in Chicago that the bees can go to for pollen and nectar. There are certain pests that get into beehives that it's not available for them to get

into a beehive if it's on a high roof because a roof is usually like tar paper. And some of these pests

Jennifer: Like the small hive beetle

Corky: Part of their life cycle is to burrow down in the ground. And then they come back up and go into the beehive. And that's obviously not possible on a tar paper rooftop or a concrete rooftop. Chicago, at least historically, they don't do a lot of spraying of herbicides or pesticides, so the bees don't have to confront that like they do in a lot of rural areas or suburban areas. And there's a lot more flowering trees and plants than you would imagine in cemeteries, along the rivers, in the forest preserves that the bees have access to. So, in a lot of ways, it's kind of counterintuitive, but a place like Chicago could be a very good place to have bees.

Jennifer: One key ingredient to urban beekeeping is an educated beekeeper. Beacon Capital Partners contracts out to The Best Bees Company to maintain the three hives. This is Sarah Long, lead beekeeper for the Chicago region.

Sarah: You're dealing with a lot of sun, which is good most of the time, but also a lot of wind. So, as with hives low down on the ground, we strap them...

Jennifer: They strap them down with ratchet straps really tight

Sarah: We use two on a rooftop hive, on the ground you might only have to use one, but we strap them to cinderblocks, so the cinder blocks are, I think they're 20 pounds each. And that keeps them tight and from wiggling around and from toppling over.

Jennifer: And the bees just seem to figure things out.

Sarah: Once we install them, they do their orientation flights, and they use the sun to figure out where they are in space and how to get out of their hive and how to get back when they go foraging. And they manage to live life on a roof.

We provide them with water a water source nearby which helps them not expend so much energy to get off the roof in order to drink. Water's what they really need to cool down in the heat of the summer, keep the hive cool.

Jennifer: On the roof, there's a sedum garden. It can get hot and windy up there, so they plant sedum—low-growing succulents.

Sarah: They do have a little bit of an irrigation system. And the bees use that. The bees seem to use the plants as well. But they go off the roof to get a more diverse diet.

Jennifer: To find forage, the bees travel all around to other rooftop gardens, the ground-level garden at Millennium Park, and even weeds in abandoned lots.

Sarah: Originally, they're from Europe—the ones that we're bringing in—the European honeybees. And, so a lot of what they enjoy are the weeds that come from Europe.

Jennifer: Clover and dandelions especially.

Sarah: All summer long we'll see just the different species rolling through in the spring, the trees we plant in the Chicago parkways, like the linden trees are really popular.

Jennifer: Also, maples.

Sarah: We found in analyses of honey they have seem to have even a lot of hydrangea and rose species, so that could include anything like crabapples and a lot of the fruit trees are in the rose family.

Jennifer: So, they keep track of the plants, but they also keep records of other key things.

Sarah: As the season goes on, we track the population numbers in each hive—how many bees are in there—we estimate that, how much brood. We track the number of mites, which is our parasite that can give the bees diseases, viruses that really hurt them and kind of run them down over the course of a season or a winter.

Jennifer: Best Bees provides this service to people who want to keep bees...but then they use some of the money to fund other research...academic research at universities around the country...which is cool because this can help people learn more about how to keep honeybees healthy.

Sarah: We want to keep the mite loads down, so all year long we're trying to check the mites, treat for the mites, and then also feed the bees and make sure they don't run out of food any point in the year because then they'll get weakened.

Jennifer: For food, she has to think about what will keep the bees fed...but also what will keep the bees dry...especially in the winter.

Sarah: We make sugar patties—because too much water is bad for them. Just like humans if you're cold, it's one thing, but if you're cold and wet, you're gonna die.

Jennifer: Surviving frigid Chicago winters can be a challenge for bee colonies...but they manage by working together to keep warm and stay fed...

Sarah: You can picture like a ball of bees—a cluster! They form a cluster to keep warm, and they surround the queen, the queen is in the center, and they sort of work their way through the food source, so if the food is all around outside of that cluster, they're good. Bees on the outside can eat—they help feed the ones on the inside, and they all rotate as well. And the bees that are getting fed can heat—they vibrate themselves to become really hot and they warm up the cluster. So, they all sort of rotate and take turns in these outside heater positions and feeding and heating. And if you have enough bodies to make it through the winter, then they can start breeding and feeding on the plants as early as February comes along. Sometimes they can breed as early as January in a tight cluster.

Jennifer: And Sarah makes sure they have the basics...

Sarah: We give them enough food. We make sure they have enough ventilation, so we don't want to shut it down completely. We keep the top of the hive sealed—they seal it with their propolis they get from plant sap

Jennifer: A sticky, glue-like substance.

Sarah: And they'll seal the edges of their hives and everything all the cracks. But they still need entrances, and that helps with ventilation. So, we have an entrance on the bottom, an entrance on the top. And then if it snows, they can get out the top. Or if too many bee bodies fill up the bottom, they could still get up the top, and come and go. They are very clean, so they need to be able to get out to defecate outside the hive. Even as soon as there's a warm day they'll get out and defecate. You'll see bee poop all over the front of the hive, and that's a good sign because that means they're moving, they're living, they're getting outside to poop.

Jennifer: In the summer, she can measure really important things...other than bee poop! She estimated they had at least 90,000 bees on the roof last summer. It takes tens of thousands of flower visits to make a pound of honey, and each hive had 8 to 28 pounds of honey last summer at the peak of honey production in late July.

So, it's possible for bee colonies to survive on commercial high rises...but is it making a difference? Here's Adam Dolezal, an entomologist from the University of Illinois. He runs a research lab that studies mostly honeybees and the stresses they encounter...like pesticides, pathogens, and nutritional deprivation.

Adam: This concept of save the bees or saving bees or bee conservation is something that I think we see in a lot of different places in the public sphere. But I think that it gets simplified, which is good for taking a complicated issue and helping the public understand it, but sometimes

we miss some of the key points about it, what saving the bees means because it can mean different things to different people.

And so it's worth remembering that honeybees are a managed agricultural species—

Jennifer: They're not native to America.

Adam: They were brought over by European settlers and they play a really critical role in the food systems really worldwide.

Jennifer: But honeybee populations on the whole are not actually seeing sharp decreases...per hive, bees are being lost...so commercial beekeepers have to make efforts like splitting hives to maintain populations...this problem is expensive...and it's distressing to have bees you're caring for die...but it's not what most people think.

Adam: Honeybees were the bee species that really called people's attention to some of the problems that bees were having. Honeybees started to have higher and higher annual losses of colonies by beekeepers starting around fifteen or so years ago. This really caught the public's eye that there were the problems occurring that were making bee colonies, something normally people don't think about particularly much, really come in the spotlight as something that was under really extreme stress in some way.

The spotlight shined on bees, and we started to talk more broadly about the other bees that are out there—

Jennifer: Especially native bees.

Adam: There are hundreds and hundreds of species of bees just in the Midwest. There's several thousand in the US. These thousands of bee species are under a lot of the same pressures as honeybees. These bees primarily are solitary. Some are social bees like bumblebees. But most are solitary bees.

Jennifer: They live by themselves.

Adam: We really don't know that much about them. There's not that many people who study them. Again, there's many different kinds all over the US. And so those same stressors we've seen on honeybees we think—well we know—are being experienced by these other bee species as well.

Jennifer: Adam says this can quickly turn into a conversation about conserving native species.

Adam: Someone from that point of view might even say we should not have honeybees around. They're an unnatural animal for this landscape. We should view them like we would beef cattle. If you're trying to conserve native animals, you wouldn't let a bunch of cattle come and eat up all the grass, you would want to keep cattle out.

Jennifer: But do rooftop beekeepers have to give up completely?

Adam: I don't think that those goals have to be at odds. I think many of the benefits that would improve honeybee health will improve native bee health as well.

Does having bees on rooftops have a tangible benefit for improving bee health or improving bees? You can see from either of those points of view, you probably wouldn't view it as particularly beneficial. That just increasing the number of colonies around in a city doesn't really help the agricultural pollination service industry, nor does it improve the abundance and diversity of a native, conservation-focused animal.

Does that mean people shouldn't do this or it doesn't have any value? Again, I don't think so.

Jennifer: Think about urban farming.

Adam: That is something people think is really great and really important, and has value, but no one would ever call that conservation necessarily—I don't think they would.

Jennifer: Is urban beekeeping the same?

Adam: It's taking something about agriculture—the production and care of an animal or a plant that has agricultural importance that you might not have the opportunity to see or learn about in a large urban area and being able to bring that in and have that present even in a big city. So, I think you can see it having an important value from that point of view.

Jennifer: We get to learn about new species of plants and animals...and, also, how to sustain life with food you can grow...a skill not known to many city-dwellers.

Adam: There's also quite a lot of work in bee health not just honeybees but native bees in urban areas. Urban areas are expanding every year. More and more of the world population is living in urban areas, so more of our land is becoming urban. So, having a better understanding of how any, all kinds of animals, but honeybees, wild bees, how these pollinators respond to these urban habitats is actually very valuable if we want to understand how the changing landscape affects these animals.

Jennifer: So it's not conservation, but urban beekeeping still has value...if you know what you're doing...and have time to dedicate to caring for and learning about bees...but what can the average person do if they want to help bee populations?

Adam: I've had people ask me many times, "Oh I'm really interested in bees. I want to save the bees, so I want to get some bee colonies at my house. And I don't really want to spend a lot of time on it. That's gonna work out right?" And I always say, "Please don't do that." Beekeeping is very challenging. It requires a lot of time, a lot of work. And, again, I'm dubious about whether just getting a couple hives out at your home improves bee health.

Jennifer: Not everyone has time to dedicate to keeping bees...but that doesn't mean they can't help pollinators...At home, people can think about not using pesticides and herbicides in their gardens...and stop killing the dandelions, which are a main source for pollen and nectar...In Illinois, people can support government programs that encourage planting diverse crops (not just corn and soybeans)...Supporting local fruit and vegetable farmers with your wallet can also help pollinators.

Most people when they think about bees, they think about honey...or getting stung...but as awareness about honeybees and native bees grows, the public is beginning to pay attention to what is most important...the health of our bees. Honeybees on the roof at the very least are shedding light on how awesome bees are. Even from 52 stories high...

Can Big Solar Installations Help Foster Biodiversity?

Published online for Sierra Magazine

At the end of last year, workers in Sacramento County, California completed construction of a 16.5-megawatt solar park on what was once open ranch land. Solar energy remains a great solution to providing clean energy, but it takes up a whole lot of land. When covered with gravel, dirt, or turf, the land suffers. It cannot be used to plant crops or to sustain diverse flowering plants and critter populations.

In December, the Rio Linda solar farm began producing enough energy to power 2,600 homes annually. Usually, the ground underneath big solar installations in the United States is scraped and covered with gravel or low grass, but if you drive by this solar farm, you'll be treated to a different view: an array of pollinator friendly native shrubs and wildflowers like purple needlegrass and California poppy. People have become more aware of the scorched earth problem that will only get worse as solar power expands.

Underneath the utility lines in the Rio Linda farm, 1.5 acres have been planted with flowering plants such as milkweed, which will attract monarch butterflies. Coyote mint and evening primrose will bloom in the summer and fall. Pollinators, like bees, moths, and butterflies, are keystone species that sustain a healthy food system. Without them, whole ecosystems, or interconnected networks of plants and animals, would collapse.

The abundance of pollinator species has been on a downturn in recent years. Western butterfly species are declining at a rate of 1.6 percent annually. The western monarch in particular declined 99.9 percent in the last four decades. Kathleen Ave, the senior climate

program manager at the Sacramento Municipal Utility District, sees solar projects that double as pollinator habitat like the one in Rio Linda as critical.

“People in utilities don’t generally think about biodiversity as their job, even though we do have influence over a lot of land,” Ave says. “[Combining biodiversity and renewable energy] is going to be an uphill battle to make it a norm, but it’s such a good goal.”

This goal takes on even greater importance in light of the Biden administration’s ambitious plans to achieve net-zero carbon emissions by 2050. Currently, solar capacity in the U.S. amounts to 97.2 gigawatts of power. Meeting the Biden administration’s climate targets will require a significant increase in the production of solar energy, but that demands massive amounts of land. Large-scale solar projects use about six to seven acres for every megawatt of energy, according to the Solar Energy Industries Association (SEIA). Scraping, leveling, and filling that land with gravel or turf presents a huge conservation issue, according to Ave. “We’re going to look back and think what an ecological disaster,” she says.

While the idea of combining solar farms and native vegetation is just taking hold in the U.S., it’s been common in Europe for years. One of the largest solar parks in the world, Lieberose, was built on a former military training ground in Germany. Several tons of munitions like land mines and grenades were removed and replaced with plant life and solar panels, which began producing energy in 2010. According to one study, some bird species at the site doubled within three years.

There are other benefits as well. According to an article by the Maine Organic Farmers and Gardeners organization, planting native seed mixes of shade tolerant plants underneath the solar panels costs about the same or less than filling the land with gravel. In addition, it requires less maintenance than low grass, as it does not require regular pesticide distribution. The soil

beneath the solar panels will be rich in organic matter and pesticide-free and could even be used to grow crops like broccoli and cabbage, which can handle shade. An added benefit is that the soil will capture and store atmospheric carbon dioxide, which contributes to the ultimate goal of reducing global climate change.

Lee Walston and his colleagues at Argonne National Laboratory examined the potential financial benefit of planting pollinator habitats beneath solar panels on solar farms across the United States. In a 2018 study published in *Environmental Science and Technology*, the researchers mapped out areas where solar energy facilities and pollinator-dependent cropland overlap. They estimated that if solar energy and pollinator conservation were combined in these locations, 3,500 km² of agricultural land would fall within foraging distance of solar projects. That amounts to more than 650,000 football fields.

Building pollinator habitats near farmland would increase visits from pollinators, which the researchers hypothesized would result in increased crop production. Even if nearby pollinator habitats increased crop yield by a mere one percent in these areas—a conservative estimate, according to Walston—production could increase by millions of dollars in pollinator-dependent crops, such as soybeans and almonds.

The idea is slowly catching on. Six states in the Midwest and East Coast have adopted legislation that allows solar sites to be designated as pollinator friendly. “As more states adopt voluntary pollinator-friendly solar guidelines, we can expect solar plus pollinator to be the norm for most future solar facilities going forward,” Walston says.

In California, which produced 22 percent of its electricity and powered nearly eight million homes using solar in 2019, the not-for-profit renewable electricity provider MCE announced last year that pollinator habitats are required for all of their new solar projects.

Lightsource bp, the company behind the Rio Linda project, also has plans to incorporate vegetation into future solar farms.

Overall, thinking about the big picture is key when it comes to the environment, Ave suggests, and this means we have to work together. “Humans—we’ve got to stop doing just one thing at a time. It’s not enough to do just renewable electricity. That’s great, and it’s better than fossil fuels, but we have to start focusing on repairing the damage we’ve done.”

Pandemic Lockdowns Did Cut Air Pollution—but With a Catch

Published on wired.com

Last April, as people around the world sheltered in place against the COVID-19 pandemic, *The Indian Express* newspaper published a photo shot by a forest ranger of the slightly hazy deep blue sky above Uttar Pradesh, the most populous state in Northern India. Above a garden trellis, the angular, white peaks of the Himalayan mountains were visible on the horizon like stiff whipped meringue. Pawan Gupta, a senior scientist with the Universities Space Research Association at NASA Marshall Space Flight Center, says that friends and family in India told him that the peaks had not been this visible for decades. The reason is simple: Before the pandemic lockdowns, the air was filled with smog.

Gupta studies air pollution in India, and like many other scientists, he's been studying how the lockdowns have decreased emissions above urban areas. "This is a natural experiment for a lot of us," Gupta says. A natural experiment that proved one thing above all—air quality can improve, and rather quickly, too.

In a study published this March in *Sustainable Cities and Society*, Gupta and his colleagues focused on three months—March to May 2020—when travel, construction, and industry outside of medical facilities were restricted. They compared air pollution metrics over six metropolises—Bengaluru, Chennai, Delhi, Kolkata, Mumbai, and Pune—to the same period during three previous years. Using satellite imaging, they found a 42 to 60 percent reduction in particulate matter and a 46 to 61 percent decrease in nitrogen dioxide (NO₂), a potentially toxic air pollutant.

Particulate matter, the scientific term for soot, includes soil, dust, smoke, and allergens. Very tiny particles can make their way into the lungs and bloodstream, making bronchitis worse,

causing heart attacks, and even hastening death. NO₂ is produced by fossil fuel combustion and can worsen asthma and increase the possibility of respiratory infections.

Gupta's colleague, Christoph Keller, a senior scientist at the same research association within NASA, has been keeping an eye on urban air pollution as well. For Keller's own study, published in *Atmospheric Chemistry and Physics* this March, he created a computer model baseline for what global NO₂ emissions would have been in 2020 without any lockdowns. Then he used surface measurements to track actual emissions in cities across the globe, including Melbourne, Taipei, and Rio de Janeiro. His results showed a worldwide NO₂ drop of nearly 20 percent, and 50 of the 61 analyzed cities showed reductions between 20 and 50 percent. Notably, Wuhan, China, showed a 60 percent reduction; for New York City, it was 45 percent.

“One of the lessons we can learn from the pandemic is that there is still a big potential to lower NO₂ concentrations,” says Keller. “What we clearly see in urban environments is there's still a lot of NO₂ that is man-made that we can really reduce by quite a bit.”

Other recent studies have echoed the same results. Marco Carnevale Miino, a doctoral candidate in engineering at the University of Pavia in Italy, examined NO₂ concentrations in three European cities. He found that it was down 80.8 percent in London, 79.8 percent in Paris, and 42.4 percent in Milan between last March and May, correlating with the traffic drop-off caused by travel restrictions. In Santiago, Chile, researchers studied urban air pollution during those same three months and compared them to the same period during the previous three years. They also found that average concentrations of particulate matter and NO₂ decreased. In Portugal, researchers found that NO₂ fell by 41 percent and particulate matter by 18 percent during the March-to-May period compared to the past five years. Researchers in the United Kingdom studied NO₂ data from January 2020 to June 2020, and again found that the

concentrations declined anywhere from 32 to 50 percent during lockdown and gradually increased upon the return of road traffic.

For the researchers, these results are a mixed bag. They show that air pollution is short-lived and dissipates once people reduce traffic and industry, which is good news. “If we make decisions based on science and informed by data, then this experiment shows that cleaner air for all is achievable,” says Gupta.

But they also show that emissions rebounded as COVID-19 restrictions loosened. Keller points out that China, the first country to engage in lockdown, saw reductions the soonest. Europe and the United States saw drops a little later in 2020. When activity in China returned to normal, so did the levels of NO₂. The U.S. saw a gradual return; notably, increases in online shopping drove up delivery vehicle traffic. As of March 2021, many places in Europe were still 10 to 20 percent below their expected baseline, Keller says.

To the scientists, it suggests that pandemic-length reductions weren’t enough. Even during lockdown, Miino points out, on several days the NO₂ levels still exceeded what is considered safe in Europe. He recommends rethinking our reliance on cars that run on fossil fuels, which are the main source of pollution in urban centers. Gupta similarly recommends reducing emissions by using fuel efficient cars, including hybrid vehicles, as well as controlling crop burning in India and reducing factory emissions. “It’s not going to go away by itself. You have to stop the pollution at the source,” he says.

Environmental advocates have similar concerns. “It is both scientifically and politically promising that we’ll see policy to improve air quality in the near future,” says Gretchen Goldman, the research director for the Center for Science and Democracy at the Union of Concerned Scientists. She points out that acute health effects, like hospitalizations due to asthma,

would decrease if we cleaned up the air. But some of pollution's long-term effects can't be reversed. Chronic exposure over years or decades can cause health problems, including respiratory and cardiac disease. "That, you can't undo," Goldman says.

Cyndhia Ramatchandirane, a staff scientist at Earthjustice, a nonprofit that does environmental litigation, sees another reason to be skeptical. "If you look at the big picture, all over the world we drove a lot less, we flew a lot less. So, from that standpoint, yes, emissions associated with those activities did reduce at different times in different places of the world," she says. "But other kinds of emissions did not." Due to the loosening of environmental regulation under the Trump administration, some U.S. factories were able to emit more pollutants than previously allowed. Extreme weather, like the winter storm in Texas, also took an environmental toll; every time a petrochemical plant shuts down and starts back up, it produces more emissions than normal.

"The pandemic slowed some things down, but business as usual is still kind of happening. Facilities are still operating," Ramatchandirane adds. "Many communities, especially communities of color and low-income communities, continued to be impacted by emissions from fossil fuels and petrochemical facilities."

The pandemic lockdowns provided a "natural experiment" for environmental researchers. However, they did not come without their own economic toll. People lost their jobs, income, and businesses. Trillions of dollars were spent by governments to keep people afloat. Shutting down so rapidly is not economically sustainable. But perhaps shifting to more remote work, scaling up renewable energy like wind and solar power, and embracing electric vehicles over time can produce cleaner air, without the economic cost.

Steve Hanke, a professor of applied economics at Johns Hopkins University, did not think the economic cost of the pandemic lockdowns justified even the public health benefits, let alone the subsequent environmental ones. When I asked him about the lockdowns' impact on air pollution, he replied, "The benefits, a reduced level of carbon dioxide, had a very short life, while the economic costs are permanent."

Karen Clay, professor of economics and public policy at Carnegie Mellon University, studies topics like mortality due to unclean air. Like all economists, Clay also looks at the cost-benefit analysis. Although keeping fossil fuels might save jobs, "the jobs don't come for free," she says. The tradeoff is loss of life. "The improvements don't come for free either," she continues, asking questions like, what is the cost per life saved? Clay advocates for environmental regulations to return at least to the level prior to the Trump administration. She's hopeful that with the support of the Biden administration, it might be easier to make things happen.

Lockdowns were hard for many, but there is still a reason to be hopeful. Almost a year ago, when *The Indian Express* shared the image of the Himalaya mountaintops on Twitter, people responded with comments marveling at the natural wonder. One person tweeted: "Please enjoy the beauty." "So mesmerizing," wrote another. One more posted: "I hope now people will appreciate what they were missing earlier."

Catching Wind

Published in Discover Magazine's May/June 2022 issue.

Capturing offshore wind in the U.S. has long been an uphill battle, with various stumbling blocks in the terrain. Objections from fisheries, skepticism from conservationists, and tenuous support from some in the tourism industry have all stalled development in the past decade, not to mention homeowners like the Kennedys and Kochs who objected to losing their view. That is, until May of 2021, when the U.S. Department of the Interior approved construction of a sprawling wind facility several miles off the coast of Martha's Vineyard. The project marks the first large-scale offshore wind undertaking in the U.S. and includes 62 turbines that will power more than 400,000 homes and businesses. But it almost didn't happen.

Under the Trump administration, the project's approval process halted, while broader national momentum behind alternative energy solutions slowed. The country's only other offshore wind facility, with just five turbines spinning off the coast of Rhode Island since 2016, looked like it would not have any company for years. That site, Block Island Wind Farm, produces 30 megawatts, or enough energy to power up to 17,000 homes. After President Joe Biden took office, however, he promised a 1,000-fold increase in offshore wind energy production in the U.S. by 2030. Approving the ambitious Vineyard Wind project marks the first big step.

The 800-megawatt Vineyard Wind farm is planned to complete construction and start delivering power by 2023. Other states on the East Coast like New Jersey are ramping up, too. As of summer 2021, the Atlantic Coast had 17 project proposals. Biden opened the West Coast to proposals in May 2021, despite prior resistance from the Department of Defense, which uses the area for testing and training in the Navy and Air Force. Industry leaders are also exploring

leasing in the Gulf of Mexico region. In October 2021, the Biden administration announced plans to consider virtually the entire U.S. coastline for offshore wind.

Hitting the 2030 goal will create approximately 80,000 jobs in the U.S. and offset 86 million tons of carbon dioxide, according to Amanda Lefton, director of the Bureau of Ocean Energy Management. “Transitioning to a clean energy future is going to be crucial,” Lefton says. Offshore wind, it seems, is finally poised as a meaningful piece of the alternative energy puzzle in the U.S.

Leveraging History

With 70 percent of Earth covered by oceans, it makes sense to utilize a sliver of the sea for wind capacity. But that comes with substantial hurdles, as the past 30 years of offshore wind progress have proven. Seas are rough and unpredictable. The cost of installation can be staggering. Massive turbines require giant ships for transport. Today, advanced technology — including blade efficiency and engineering, floating turbines, and even flying drones — place the transition to offshore wind within reach.

Over the past hundred years, interest in wind power has waxed and waned. It remained more costly than electricity generated with fossil fuels. The financial investments in the industry started picking up in 1970 when oil prices hit a high, which significantly stimulated the market. In the next couple of decades, Congress and many states passed laws that required companies and utilities to purchase a certain amount of power from renewable sources and provided a tax credit to businesses that used wind as an energy source.

While the U.S. stuck to land, Denmark became the first country to dip its turbines in the water 30 years ago. When you look at a map of the country’s wind farms today, the sea looks

like a loud geometric print, filled with color-coded designations of massive offshore wind facilities, many already in operation. The pilot project was up and running in 1991. Another 15 offshore farms have rolled out since then. Neighboring European countries, such as Germany and the Netherlands, have also invested in offshore wind since the early 2000s, the bulk of the work happening in the past decade. On a comparable map of the U.S., multiple proposed projects have popped up along the northeast coast in just the past year.

“The U.S. now is where Europe was 10 years ago,” says George Xydis, an assistant professor at Aarhus University in the Center for Energy Technologies in Denmark.

As the U.S. now looks to the sea, this relatively late start poses some advantages, according to Xydis. Scientists have learned from the past three decades of work in Europe. They are equipped with elements like more advanced blades than ever before and the latest knowledge on how best to place 800-ton metal machines in the ocean.

The Advantages

As offshore wind developed in Europe, increasing concerns about conservation and biodiversity—the threats to plant and animal life because of wind projects — pushed engineers to build larger offshore turbines. If each individual machine were larger, it would produce more power, and less-expansive sites — thus less disruption to plants and animals — would be required. Today, a larger offshore wind turbine can produce five times the power of an average onshore turbine.

Additionally, at some point, engineers will need to replace blades and entire wind turbines and dumping the gargantuan metal objects into landfills isn’t exactly sustainable. Denmark-based Ørsted, which is the biggest offshore wind developer in the world, announced in

2021 that it would recycle or reuse all decommissioned wind turbines going forward. Materials like thermoplastic resins can melt down and be repurposed.

In terms of the environmental and social impact, offshore wind is actually easier to develop than land-bound projects, according to Xydis, an engineer by trade who also holds an adjunct position at Johns Hopkins University. While completing his Ph.D., Xydis worked in the energy industry. “There are more constraints with onshore wind,” he says.

Primarily, onshore wind requires a massive slice of land. Beyond that, developers need to avoid harming the birds and mammals that already inhabit the land and air the farm will occupy. Finally, people who live nearby need to tolerate the constant whirring noise the windmills generate as well as a shadow that consistently comes and goes as the turbines turn. (Just Google “shadow flicker” for a glimpse of the controversy.)

The U.S. is well on its way to adopting wind power more widely. In 2008, the U.S. Department of Energy declared a goal of achieving 20 percent of all electricity generated to come from wind energy by 2030. As of 2020, the country was at 8.4 percent, with nearly 100 percent of that coming from landbound systems.

Onshore wind and solar power generation costs can now compete with fossil fuels. Offshore wind costs will likely drop in the future as well, according to a July 2020 study published in the journal *Energy*. The study predicts that Europe will move toward developing offshore wind farther from shore, where the wind gusts at higher speeds and generates more power, thus providing more return on investment. Developers will see profit more quickly, and the price of renewables will drop for the communities nearby.

Inspections have also seen technological advancement. Huge spinning blades pose dangers to people who inspect the blades. Nearthlab, a South Korean company, touts their

autonomous drone technology as a safer, more efficient way to perform inspections. In the same way it has implications for onshore wind, it helps developers solve the safety inspection problem with offshore wind too.

The Downside

With the many reasons to expand into the oceans, there are some people who have reasons to stall the progress of offshore wind in the U.S. Along with objections from the fishing industry, the U.S. military has also resisted relinquishing sea space to the energy sector. According to a 2021 NPR article, the Navy released a map in 2017 putting areas of the Pacific Ocean off limits to offshore wind. It took three years of negotiations before a compromise was reached. Because of these necessary negotiations, the approval process for wind projects can drag on for several years, which includes weighing the impact on the environment, recreational activities, and tourism.

Niels Erik Clausen, associate professor at Technical University of Denmark in the department of wind energy, says constraints still exist with offshore wind after decades of progress — they are just different than those onshore. Besides the enormous economic costs of such projects, construction noise, for example, may disturb marine mammals like whales, dolphins, and seals. Seabirds potentially won't return to the area, which can harm the marine ecosystem. Back in 2014, in fact, an offshore array in the U.K. was cancelled after a decade of work on the project because of uncertainty about the survival of the red-throated diver, a protected seabird.

On the other hand, these projects pose some potential benefits to sea life. “If you’ve been snorkeling, you’ll find there’s a lot of marine life around shipwrecks. The same is true with

offshore wind,” Clausen says. Some argue that the turbines can serve as artificial reefs. Others claim the ecosystem benefits because the turbines make it more difficult to fish. For this reason, the fishing industry worries that their livelihoods will be affected by fishing restrictions.

U.S. Bureau of Ocean Energy Management (BOEM) researchers still puzzle over how turbines in oceans affect birds and fish. They recently started trying to assess the impact through the Realtime Opportunity for Development Environmental Observations project, which conducted research when the foundation work began on Block Island in 2015. The researchers will report on other offshore wind projects as operations begin in the next several years. So far, they’ve found that during the noisy pile-driving phase of construction, the abundance of winter flounder decreased. However, other kinds of flatfish were not significantly impacted. The researchers also noted that almost immediately, mussels, sea stars and anemones began covering the submerged turbines. Overall, future study in this area may benefit the industry by providing data to justify construction and to illuminate how it impacts marine life.

If determining the ecological cost proves difficult, pinpointing the economic cost is perhaps more so: “Calculating this is super complex,” Xydis says. Factors to consider include wind speed (because higher winds generate more power), financing schemes, and capital costs for structure foundations and the cables, often buried beneath the seafloor. In an area with very high wind speeds, it may take just under 10 years to pay off the investment. But, Xydis says, it can range from roughly five to 15 years to reach profitability.

Looking Ahead

Although some people have legitimate reasons to object to placing metal machines in the ocean, the shift to offshore wind is happening with the support of the Biden administration. As

time passes, wind technology will only keep advancing, says Walt Musial, the offshore wind principal engineer at the National Renewable Energy Laboratory (NREL), a federally funded research center. The machine height and blade size have only increased and become more efficient at capturing energy — since 1998, for example, the swept area of the blades has increased by 570 percent.

The next phase of offshore wind, Musial says, touches on a different area: floating wind turbines. This opens access to deeper waters and potentially reduces development costs by avoiding fixed-bottom foundations. At NREL, Musial works on harmonizing hydrodynamics and aerodynamics to facilitate these more advanced wind farms. Although the floating industry is younger, Musial says it holds a promising future. Most European offshore wind developments as well as many planned for Asia have floating potential. “The pipeline for floating is growing exponentially,” Musial says.

Still, countries need to step it up to meet the sustainable development goals put forth by the International Energy Agency (IEA), a Paris-based intergovernmental organization. The IEA found that offshore wind generation must grow: Non-European countries must adopt the same advancements in the wind sector that Europe has over the past decade. Although some financial incentives exist in the form of government tax credits, more can still be done to incentivize businesses to use renewable energy, like developing binding financial agreements.

Pushback is still inevitable. To get ahead of resistance from the fishing industry, Vineyard Wind has hired a fisheries representative to work on their team. Commercial fishers may still raise objections to the Vineyard Wind project. But Lars Thaaning Pedersen, the CEO of the Vineyard Wind company, insisted that “the fishing industry and offshore wind can coexist” at a September 2021 press conference.

The fishing industry might have reason to be concerned. The Port of New Bedford handles millions of pounds of seafood each year. They have a rich history of providing hundreds of millions of pounds to both the U.S. and other countries. I talked to Kate Will, a 25-year-old paralegal who hopes that there will be a shift from historically celebrating fishing and whaling to the new offshore wind industry. Will enrolled in two classes to prepare for a career in offshore wind. “I think this will have a huge impact on the community,” Will says.

And Denmark, the global leader in the industry, is not slowing down. In June 2021, Ørsted announced that it would invest more than \$57 billion in renewables by 2027, about 80 percent of that going to offshore wind and hydrogen projects. The Danish government also greenlit plans to build an artificial island as a hub for hundreds of offshore wind turbines — enough to power 10 million households — complete with a hotel to house staff. The first phase alone, scheduled for completion around 2033, will be the size of 18 soccer pitches. The scale sets an ambitious precedent for the U.S. and other countries.

Behind the Push to Reduce Emissions from Marine Shipping: What's Standing in the Way?

Chances are, like most Americans, you ordered products online during the pandemic lockdowns. The ease of having products delivered right to us is appealing, but the journey it made to arrive at your doorstep is often not top of mind. With many online product deliveries, the products travel on giant cargo ships before they make it into your home.

Three percent of the greenhouse gas emissions that humans generate can be attributed to the marine shipping industry, and approximately 90 percent of goods have been transported on a ship at some point in their life cycle. “It’s a foundation of the global economy and is not going away any time soon,” says Dr. Jake Russell, a fellow at the Advanced Research Projects Agency - Energy (ARPA-E), who focuses on reducing carbon in maritime shipping.

One of the reasons why scientists call for action so urgently is, in part, because of the long life of a ship engine. The engines that are built today will likely still be traveling across the ocean in another three decades. As black stacks funnel smoke from tops of ships into the atmosphere, the ocean also absorbs about 30 percent of those carbon emissions. When the ocean absorbs carbon, it increases the acidity of the water, which in turn harms organisms like shellfish and coral. The ocean is warming, too, which contributes to natural disasters like hurricanes.

Right now, some of the options for reducing emissions from shipping, like green hydrogen and green ammonia fuels, come with a hefty price tag. Dr. David Babson, program director at ARPA-E, says that right now “the cost of electricity is high, the cost of the reaction equipment is high, and the carbon intensity of the electricity on our grid presently is too high to make it reasonable.”

Producing these fuels with the current grid sometimes emits carbon itself. Although the technology exists to produce hydrogen and ammonia without emitting carbon, like by using renewable energy in the production process, it's still too expensive to make it the norm. Before green fuels become more practical, transition fuels could also be an alternative. Companies like the SeaChange Group are working on bringing a biodiesel fuel to market in the next couple years. While their fuel still is composed of one-third petroleum, the other two-thirds is completely renewable.

Several reasons exist for why people might make the switch to a transition fuel. People in shipping can avoid hefty fines for polluting the air and sea. It is a "slippery" fuel, so the engineers think it would reduce wear and tear on engines, reducing maintenance costs. And then there's the human health component—reducing greenhouse gas emissions on ships would decrease air pollution, which is known to cause respiratory issues, like asthma and lung cancer. "We are where we are now," says Geoff Lamdin, founder of SeaChange Group. "Maybe hydrogen and electricity represent where we're going somewhere out in the future."

Another option is carbon capture. Although a pilot lab in Norway is researching how carbon capture could be used on ships, and one at the University of Michigan is investigating how they could do this on semitrailers, Travis Schmauss and Scott Barnett at Northwestern University looked to the future of carbon capture on ships in a recent paper. They want to use solid oxide fuel cells to go carbon neutral or carbon negative on large ships.

In their recent article, the colleagues drew up a schematic for an apartment-sized cell with a movable partition that would sit under these enormous ships, storing fuel on one side of the cell and capturing carbon on the other. The system superheats ethanol and passes it by a catalyst, which breaks it into a hydrogen molecule and carbon. It then adds oxygen to each, creating water

and carbon dioxide. The water drips out, and the carbon dioxide is sucked into a compartment. The solid oxide fuel cells would never dilute the carbon with air, creating a closed loop system. The fuels could be anything from fossil fuels to biofuels to electrolytic fuels produced with renewable energy.

The carbon is stored in the cell with the movable partition or in a separate tank altogether. Once the ship's journey is complete, the carbon would be sequestered; that is, it's injected and stored either on land or beneath the sea floor. Another option would be to "recycle" the carbon to make more fuel. Compared to alternative fuels, his carbon capture system remains the only solution out there that has potential to be carbon negative.

Babson tends to think, however, that carbon capture may not be the best solution for long-range ships. Fuels that power ships are energy dense, which means they store lots of energy in a small space. It's not practical to have a giant cell below the ship. Burning 100 gallons of diesel results in 1 ton (almost 600 cubic meters) of carbon dioxide. Schmauss maintains that when it comes down to economics, their carbon capture scheme would remain attractive to shippers because they could keep using inexpensive fuel and reap the environmental rewards.

Schmauss argues that if the cost of fuel can be kept low, like it would if ships installed carbon capture cells and could still use fossil fuels, then shipping can remain profitable; yet, the substantial cost to install the cell initially remains. Another option is producing battery-powered ships. For these very large ships, like cargo vessels, a battery-powered ship would simply not make the journey. But when you look at smaller boats, like tugboats, battery power would be more realistic.

Schmauss and Barnett's carbon capture cells still exist only in the conceptual world—there is no prototype yet. "It's a concept we checked the viability of," Schmauss says. "We're

doing the materials science—what the stuff is made of.” Yet, he persists in defense of their work, saying: “Nothing else is going to actually remove carbon.”

This issue is complex, to be sure. With green hydrogen and ammonia, batteries, and carbon capture, as well as transition biodiesel fuel, there are so many options, and so many reasons to move forward, but still so many caveats. Much of this, it appears, will be a game of wait and see as scientists push to reduce emissions from marine transport.

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Author's Biographical Sketch

Jennifer Clare Ball grew up in Wheeling, Illinois. She graduated with a B.S. in Journalism from Northwestern University. She enrolled in the M.A. in Science Writing program at Johns Hopkins University in the summer of 2019. Jennifer is a manuscript editor for the American Medical Association, and she also writes freelance articles about issues affecting science and society, such as the opioid epidemic, pandemics, urbanization, and climate change. During her time in the M.A. program, her words have appeared in Wired, Popular Science, Sierra Magazine, Earth Island Journal, Women's Media Center, Johns Hopkins Magazine, The Xylom, and Discover Magazine. Jennifer likes to travel and explore new locations in her downtime. She lives in the northside Lincoln Park neighborhood of Chicago, Illinois.