SciencePodcast_210430

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0:00:05.8 Sarah Crespi: Welcome to the Science Podcast for April 30th, 2021. I'm Sarah Crespi. Each week we feature the most interesting news and research published in Science and the sister journals.

0:00:16.3 SC: First up, we talk gravity batteries, which are basically a way to store renewable energy from sun and wind in heavy things held high off the ground. For that story, we talk with contributing correspondent Cathleen O'Grady. Then we talk with researcher Erick Lundgren about how feral donkeys and wild horses can engineer the desert by digging wells and supplying water to the ecosystem.

0:00:46.0 SC: Now, we have contributing correspondent Cathleen O'Grady. She visited a demonstration facility in Edinburgh, where a company is testing storing renewable energy from wind or from solar in gravity batteries. Hi, Cathleen.

0:01:00.0 Cathleen O'Grady: Hi.

0:01:00.0 SC: You actually got to travel for a story, which I think has been a long time coming. Can you set the scene for us? These gravity batteries are really, really big. Can you talk about what the one that you saw looks like?

0:01:15.8 CO: The people on site said that a lot of people remark on how huge it is, it's this 50-ton weight, it looks kind of like a big elevator, if you imagine an elevator shaft that's just been taken out of a building and put naked on a dock, but they kept emphasizing that this is actually the miniaturized version and...

0:01:32.9 SC: Wow.

0:01:33.0 CO: The eventual version that they're aiming for is going to be at least 10 times bigger.

0:01:36.4 SC: 500 tons.

0:01:38.1 CO: Yeah, that's the weight that they're amino, and then they're planning to have multiple 500-ton weights in the full size plant.

0:01:46.5 SC: So they take renewable energy and they want to save it for later and they basically convert it to potential energy by winching up this heavy weight. How does it come back out when there is a high demand in the grid and the sun isn't shining and the wind isn't blowing?

0:02:01.9 CO: When the wind is blowing, you can store up that energy by running that through an electric motor, the electric motor spins, uses steel rope to lift up this weight to the top of the tower, and then it can just hang there, and when the wind stops blowing and you need to release the power, this weight can slowly lower down the shaft and as it lowers, it's tugging that rope with it, and the rope is spinning that motor in reverse, and it becomes a generator that's sending electricity back to

the grid.

0:02:26.8 SC: This is a testing facility. They were trying it out. Were there hang-ups?

0:02:30.9 CO: What I found really interesting is talking about all the tiny little nitty-gritty things that they've had to work through, so the principle is incredibly basic, but one of the things that they've had to deal with is the fact that these steel ropes, like any other rope, they're multiple strands twisted around, and if you think about hanging a weight at the end of a rope and you lift the rope, that weight at the end of the rope is going to spin, the rope is going to want to untwist itself.

0:02:55.2 CO: And so there are these forces operating on the 50-ton weight exerted by the rope, they have to factor in the wind, all of these different forces that are pulling the weight in different directions, and that will affect its motion and its efficiency, so they're working through little teething issues like this to get the system operating at the efficiency that they're aiming for.

0:03:13.0 SC: There are a few other versions of these gravity batteries out there, you talk about variations on what is being lifted. So it's not necessarily just a giant weight, some of them involve water. Can you talk about these other approaches that you included?

0:03:28.0 CO: They're all kind of operating on this basic idea that you have to lift something heavy and then when you lower it, that potential energy gets released. But some of the designs are closer to the old idea of pump hydro, which involves pumping water uphill and then releasing that to turn a turbine, old-fashioned hydroelectric power. So some of them instead of pumping the water uphill, they're pumping it under a piston-like weight in a tube, and they're pumping water under it, so the piston rises up the tube, and then when they want to release the power, they lower the piston and the piston forces that water out of the tube and through a turbine.

0:04:04.9 SC: And what about this one where they build a building?

0:04:08.7 CO: This is very, very cool. This one took me a while to get my head around, but it's essentially a very large crane with six arms in a star shape at the top, and and each of those arms can attach to multiple 35-ton bricks, and it lifts this brick and builds like a huge power of these bricks, using the same principle as the site that I saw, where there's just a motor pulling the brick up, and then they stack these bricks and when they're ready to release the energy, a crane picks up a brick and lowers the brick and the same idea, the brick is then turning the motor in the other direction, it becomes a generator and releases it. So it's just like assembling and disassembling power of bricks.

0:04:48.7 SC: Wow, that's amazing. So how efficient are these systems?

0:04:54.6 CO: Gravitricity, which is the company whose test site I visited, they're aiming for 90% efficiency, so 90% of the energy that they were storing with their lifted weight they're hoping to be able to send back to the grid.

0:05:08.1 SC: And how much do they expect they could store?

0:05:09.8 CO: The test plant can only deliver up to 250 kilowatts. Gravitricity is hoping that their initial commercial system will be around 4 megawatts, but they're hoping to go up to 10 megawatts for the biggest system that they're currently designing.

0:05:26.4 SC: This is going to be using a mine or some kind of deep shaft, so that you don't have to consider as much of the outside influence, and you also don't have to build a really strong platform.

0:05:37.8 CO: Exactly. Even for the test plant, they had a hard time finding a site that would be able to kind of withstand the forces that are operating on their shaft with a very heavy weight. So if you scale up that weight to 500 tons, and then you have multiple weights that size, the foundations that would be required to support that would be absolutely extreme, so instead they're looking to go underground and use decommissioned mines where the shafts are already built, and just convert those into gravity storage.

0:06:06.6 SC: Well, how about lithium-ion batteries? These are getting very large and they're being used to store renewable energy. How do they compare with what we're talking about here with gravity batteries?

0:06:16.9 CO: Yeah, so they have some advantages and disadvantages. They already have a huge foothold in the market, which means that investors trust the technology, they have the advantages of massive scale, which makes it easier to lower costs because they're already kind of everywhere. Gravity is a late-comer to the market, which means that these very small startups don't yet have those advantages, but they do have other advantages working in their favor. For one thing, they're able to work with much more environmentally-friendly materials, they're not relying on the mining of cobalt and lithium, which comes with environmental and human rights concerns, and they also do have the possibility of being cheaper than lithium-ion batteries.

0:07:00.8 CO: So one estimate, which was done based on Gravitricity's own numbers, so it still needs to be validated, but one estimate puts Gravitricity's technology at half the price per megawatt hour compared to lithium-ion batteries, and they potentially have a longer lifespan, because batteries charge and discharge and after a while their capacity reduces, whereas if you're just lifting a heavy weight and lowering it in, you don't have that problem. So it's still kind of up in the air whether these technologies will actually be able to go ahead and get a foothold in the market, but it's not impossible that they'll be able to pull it off.

0:07:35.0 SC: I was thinking about this as how distributed it can be if they have to be so massive. Are we going to have little, I guess not little, large gravity batteries every couple of miles around cities?

0:07:50.1 CO: I have no idea. That's quite an image. I can't imagine a six-arm crane or a little shed above an elevator shaft on a wind farm. I guess that's maybe not too difficult to contemplate, but I guess we'll have to see.

0:08:03.5 SC: I can imagine also an art installation that is also an energy storage system.

0:08:09.7 CO: That is a brilliant idea. I would love to see that.

0:08:11.5 SC: Gravitricity is in Edinburgh, Scotland, which has a long history in the energy industry. Do you see this as kind of a continuation of that tradition?

0:08:23.1 CO: It was really funny, because right next to Gravitricity's shaft on the docks of Edinburgh is an oil rig supply vessel that's going out to supply the North Sea oil rigs with food and equipment and other supplies, so there's kind of this echo of this old technology, right next door to Gravitricity. But Gravitricity's little shed has about 16 bikes leaning against it, everybody who works on the site arrives by bike most of the time, to the extent that if you arrive by bike at the docks, they guess that you're going to Gravitricity's site.

0:09:00.0 CO: So it was this really interesting kind of vision of Scotland's renewable future. Scotland's kind of leading the charge on offshore wind, has led the charge on marine turbines, and it's kind of exciting to have this storage technology and development here too.

0:09:14.8 SC: Great. Alright, thank you so much, Cathleen.

0:09:17.2 CO: Thanks so much for having me.

0:09:19.2 SC: Cathleen O'Grady is a contributing correspondent for Science. You can find the link to the story we discussed at sciencemag.org/podcasts.

0:09:27.6 SC: Feral donkeys and wild horses are known to dig wells in dry lands. Who else benefits from these water sources? Erick Lundgren joins us next to discuss.

0:09:46.2 SC: This week in Science, Erick Lundgren and colleagues write about the role of feral donkeys and wild horses in providing water sources in dry lands. Erick is here to tell us about what these equids are up to. Hi, Eric.

0:09:58.5 Erick Lundgren: Hi, Sarah. Thanks for having me here.

0:10:00.2 SC: Oh, sure. I don't think many of us knew that a feral donkey could dig a 2-meter deep well. Is this curious behavior kind of what kicked off this area of research for you?

0:10:12.4 EL: Yeah, it really was a kind of a life-changing moment. Ten years ago, I was working as a field technician in an area with lots of wild donkeys, wild burros in Arizona, and there are these incredible features to ground water, and it really did bring up a lot of questions in my mind about the role of introduced species and what these animals were doing in these landscapes.

0:10:31.6 SC: And you call it engineering in the paper. Why do you think that term is appropriate for what's going on with the well-digging that they do?

0:10:38.8 EL: We talk about ecosystem engineering in terms of the behaviors or even just the fact that organisms in their life, like a tree in a way is an engineer, but by changing the abiotic

environment around them, certain organisms can really strongly facilitate other species and processes. The most notable thing about deserts, of course, is the scarcity of water, and these animals can really enhance the availability of it through drought and in the hot summers where natural sources of water tend to dry up.

0:11:07.9 SC: You looked at the downstream effects of these equid wells on deserts in Arizona and California. What kinds of changes were you looking for, were you trying to quantify those things that you were just talking about?

0:11:23.3 EL: Yeah, we started by just wanting to describe this, how significant is it, are these just little tiny holes or are they actually contributing something substantial to the amount of water in these systems? And so we were looking at these groundwater-fed streams in the desert through the summer months and surveying the amount of water in them. And these streams have lots of water in the spring, following the winter rains, and then as temperatures increase in the summer, these places tend to dry out and the water tables drop sub-surface.

0:11:52.0 EL: And these equids were digging down and maintaining access to the water table. And one site, the stream went entirely dry, and the only water available were in these feral donkey holes. In other sites, we'd have a stream that might be 2 kilometers long that used to have water through most of it, and all of that dries up, except for a small headwater pool, which usually gets really skanky and gross by the middle of summer. And there is water throughout the entire reach in these clusters of wells that the donkeys and horses dug.

0:12:21.9 SC: So when you watched these wells, basically when you observed who is visiting them and when, what more did you learn from that method of research?

0:12:30.4 EL: Yeah, so we put cameras on these wells as well as other sources of water, and we paired these with dry controls in the same systems. And as you'd expect, many organisms used the water in these wells; pretty much everything in these systems did. We detected total of 57 species definitively drinking from donkey wells and many other species that we couldn't be definitive, but were on their way to getting into the water and drinking from these. This is pretty incredible. Going into the sites when it's 115 degrees and there are squirrels and warblers and orioles trying to get and drink the water right next to your feet.

0:13:06.7 SC: How common is this? Are there a lot of these donkey wells?

0:13:11.7 EL: Their ability to dig is constrained, it seems, by the type of sediment, so they don't seem to dig in really heavy compacted cobbles and steep mountain drainages, but in these flood-disturbed systems that are really characteristic in many parts of the Sonoran and Mojave deserts, you'll find clusters of wells at places where the groundwater is pushed up. In the winter and in the spring, you'll find wells all over the place, but as the water table drops further, they seem to know or be able to smell where the water is, and they'll dig quite selectively and create these zones where there might be 30 wells over maybe 100 square meters.

0:13:47.1 SC: We talked about some of the animal visitations that you saw at the wells, but there's

also an effect on the plants in these regions. Can you talk a little bit about how the donkey wells affect what grows and where?

0:13:58.4 EL: Where this all started, where I first started observing this behavior, it's on this really amazing river in Western Arizona called the Bill Williams River, and I was working there for the United States Geologic Survey looking at how floods influence the riparian dynamics, the vegetation dynamics of these rivers, which we call riparian ecology. And in particular, how floods can influence the germination and establishment of trees like cottonwood trees, which are really these foundational charismatic trees that support many bird species, migratory birds, raptors.

0:14:31.1 EL: And these wells were just full of these trees, these cottonwood trees, and these cottonwood trees are particularly interesting because they're dependent upon floods, and many of these systems in the Southwest and around the world no longer have the flood disturbance regimes that they used to have because of damming. And in the absence of these floods, you get new, novel vegetation communities of plants that are not as flood-dependent. But what's interesting is that in these non-flooding years on this river, these burro wells appear to mimic the types of influences that floods drive.

0:15:02.0 EL: And so we looked at germination of these trees and these actual burro wells and at undisturbed surfaces, and there was significantly higher germination in these wells, which persisted after typical summer mortalities, showing that these trees were establishing.

0:15:17.8 SC: So how would you kind of summarize the overall influence of these wells on the ecosystems that the burros and wild horses are living in?

0:15:26.4 EL: I guess the way I think about it is almost like a buffering mechanism. There's so much variability in these types of systems in terms of water availability, and this behavior appears to mitigate that, the drasticness of those changes. I think that's particularly relevant when you think about increasing aridification, increasing temperatures. And there's a fossilized, what appears to be a well dug by a mammoth in Western North America 12,000 years ago, which may have been in response to a drought at that time. And so it seems like this is something that was probably present for 30 million years, and playing roles, particularly during periods of aridification.

0:16:07.4 SC: Burros and horses are not native to this region. How did they end up there? And should we appreciate them more than perhaps we have before?

0:16:17.5 EL: These introduced equids have a diversity of effects on ecosystems. They are all descended from domestic organisms that were brought to North America for use in our economies as beasts of burden or transport, and then were freed or escaped on their own. And they present a bunch of questions, one of which being, how do we understand their presence in these landscapes, knowing full well that there used to be many species of equid as well as many other big animals in the North American landscapes and South American until the extinctions of the late Pleistocene... I would suggest that we think about these organisms more broadly and relax our ideas of nativeness, which often constrain what kinds of questions we ask about ecosystems.

0:17:02.6 SC: And how we consider conservation.

0:17:06.4 EL: Exactly. If we broaden our perspective, we find new phenomena. What's interesting about this well-digging is that it's common, and many people have seen it, but no one's ever described it. It's like it's never been scientifically valid because it violates our narratives about good organisms and bad organisms.

0:17:28.6 SC: You know, it is interesting to think about a burro recapitulating something that a mammoth used to do. If mammoths did this, if horses did this... Well, we're kind of focusing on this one quadrant of North America, is this happening elsewhere? Are, I don't know, hoofed things or big things digging holes, helping everybody else out in other parts of the world?

0:17:48.7 EL: Yes, well, first of all, feral horses and donkeys have been documented doing this in South America and in Australia. In Australia, prior to the eradication of donkeys from the Kimberley, which has barely even stopped, there's one population left, but the helicopter pilots who did that eradication have described to us seeing strings of wells, like little beads in all the dry creeks in the Kimberley, until these animals were killed.

0:18:13.3 EL: Feral horses in Queensland have been documented digging wells deeper than their own height, describe disappearing into the wells they dug. These aren't the only animals. Other equids, almost all equids dig wells. So we know about this behavior in Mongolia and in Africa where equids have survived. We also know that elephants, both African and Asian elephants, dig wells, and that's actually how I first noticed this, because I'd just read a book by Katy Payne about elephants in Africa, describing this behavior and how it provided water through the dry season.

0:18:44.5 SC: That is amazing, thank you so much, Erick.

0:18:47.3 EL: It's been great to be here, Sarah. Thank you.

0:18:49.0 SC: Sure. Erick Lundgren is a post-doctoral researcher at Aarhus University. You can find a link to the paper we discussed at sciencemag.org/podcasts.

0:19:00.2 SC: And that concludes this edition of the Science Podcast. If you have any comments or suggestions for the show, write to us at sciencepodcast@aaas.org. You can listen to the on the Science website at sciencemag.org/podcasts. On the site, you can find links to the research and news discussed in the episode, and of course, you can subscribe there or anywhere you get your podcasts.

0:19:21.8 SC: This show was edited and produced by Sarah Crespi with production help from Podigy, Meagan Cantwell and Joel Goldberg. Transcripts are by Scribie, and Jeffrey Cook composed the music. On behalf of Science Magazine and its publisher, AAAS, thanks for joining us.