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Wind Could Power Future Settlements on Mars

A crewed expedition to Mars has been a century-long subject of fascination and, for now, fantasy. The basic engineering challenges are enormous: To start with, there's the question of where to find a viable and steady source of energy, which would be required for any human mission to Mars. The answer to that question may be blowing in the Martian wind, according to a new study.

Solar and nuclear energy have traditionally powered robotic missions. But nighttime shutdowns and dust storms disrupt solar energy generation, and waste disposal is a huge concern for nuclear power.

Wind power has been explored in the past, but with the atmospheric density of Mars being 1% that of Earth, much larger turbine blades would be needed to generate sufficient energy from comparable wind speeds. In addition, the Viking and InSight lander instruments recorded low wind readings, although these sites were, by design, quiet wind zones. Wind was dismissed as not viable.

Now, a study published in *Nature Astronomy* has suggested that wind energy could, indeed, be harnessed to power human settlements on Mars (bit.ly/Mars-winds).

"We were excited to find that there are many locations across the planet where winds are strong enough to provide a really stable power resource" and compensate for a shortfall in solar power using wind turbines, said Victoria Hartwick, lead author of the study and a postdoctoral fellow at NASA Ames Research Center. She and her team tailored a climate model designed for Earth to simulate Martian climatic conditions and assess winds on the Red Planet.

Tools for the Job

A new NASA Ames Mars global climate model factors in not only standard fluid flow but also elements specific to Mars, such as how the atmosphere interacts with the surface.

The new model uses topographic, heat storage, and albedo and dust maps from prior Mars observations. It simulates wind patterns and strengths across the entire surface and their variation with time of day and season, and during years with and without dust storms.

The researchers measured a potential turbine's maximum and actual power production and compared the results with the maximum available solar power across seasons, time of day, and dust activity, noting where power levels exceeded theoretical power requirements for a crewed mission to Mars.

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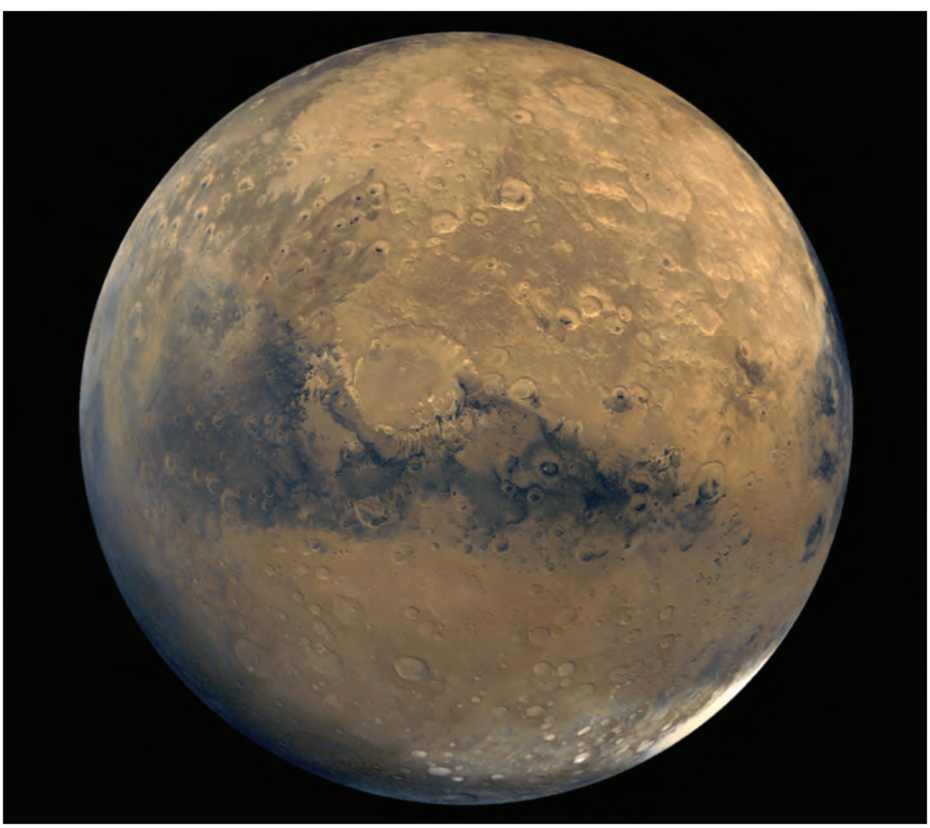


Future Mars missions could be powered by wind. Credit: NASA/JPL-Caltech/USGS

The Answer, My Friend, Is Blowin' in the Wind

The model revealed that wind power on the Martian surface peaks in the midlatitudes and poles during each hemisphere's winter; at night, dawn, and dusk; and during dust storms that occluded sunlight. Slope winds, similar to thermally driven mountain and valley breezes on Earth, are particularly strong on Mars along crater rims and down volcanic highlands. Akin to Earth's land and sea breezes, the temperature contrast at the winter poles creates powerful polar vortices. These sites had the highest wind power potential.

The researchers identified 13 new regions with good wind potential and confirmed that 10 prospective landing sites identified by NASA have sufficient wind for energy generation. "Some regions—for example, in the midlatitudes and poles, with fascinating geologic histories, and close to subsurface water ice deposits that could be valuable resources for a human mission—that had been previously dismissed on the basis of estimated solar power availability are back on the table," Hartwick said.

"This is a really interesting and useful first step along the way [to human exploration on Mars]," said Bruce Banerdt, a planetary geophysicist at NASA's Jet Propulsion Laboratory and principal investigator of the InSight mission, who wasn't involved in the research.

Don Banfield, a planetary scientist at NASA Ames who also was not part of the study, agreed. "This work has not been done before. They did a nice job of looking at how wind power resources might be distributed on Mars."

The next step, Hartwick said, will be to use an extremely high resolution weather model and zoom in on those regions to get a better sense of small-scale wind variations in response to the local topography and other unique atmospheric changes.

"They've used a very well established model for analyzing Martian winds," Banerdt said. But "we still have only limited ground truth on Mars" against which to directly compare the data, he added.

NOAA Geophysical Fluid Dynamics Laboratory's Lucas Harris agreed that given the limited direct observations available on Martian winds, "the validation of the model is similarly limited," adding, "I don't think that's going to be a showstopper, though. This is neat stuff."

"This is neat stuff."

A Tale of Turbines

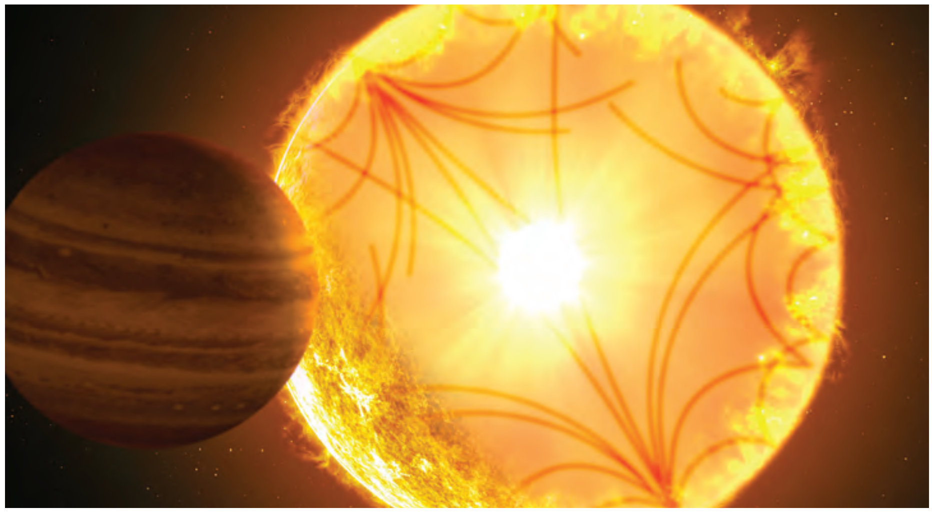
"It is unlikely that we'll see big wind turbines on Mars in the near future, unless SpaceX's Starship proves successful," said Banfield, who was part of an effort to develop a turbine to sustain a polar mission on Mars. "But I do hope that we'll develop small ones."

Isaac Smith of York University in Toronto, who was part of that same effort, also pointed out the logistical constraints and costs of transporting equipment to the Red Planet but added, "Wind energy gives us another tool to use on Mars, that we might not have otherwise."

"This paper is a fantastic resource for those planning human or robotic Mars missions and demonstrates that wind energy should not be discounted," said Claire Newman, a dust storm expert at Aeolis Research who has worked on the InSight, Curiosity, and Perseverance missions. "I would love to see Mars's wind energy explored further."

By **Alakananda Dasgupta** (@AlakanandaDasg1), Science Writer

"Hot Jupiter" Is in a Possible Death Spiral



Kepler-1658b is spiraling closer to its star in this artist's rendering. Credit: Gabriel Perez Diaz/Instituto de Astrofísica de Canarias

A distant planet is in a death spiral and is poised to be engulfed by its parent star.

Kepler-1658b is the first inspiraling planet discovered around an "evolved" star—one that has moved out of the prime of its life. The star—Kepler-1658—is about 1.5 times the mass of our Sun and has expanded to almost 3 times the Sun's diameter in its late stages of life, earning it the designation of subgiant.

Should Kepler-1658b maintain its current path, it will meet its fate in about 2.5 million years.

As the complicated discovery of the planet and its star has shown, however, nothing is certain. "It's a very confounding system," said Ashley Chontos, a postdoctoral fellow at Princeton University and a member of the team that discovered the planet's shrinking orbit.

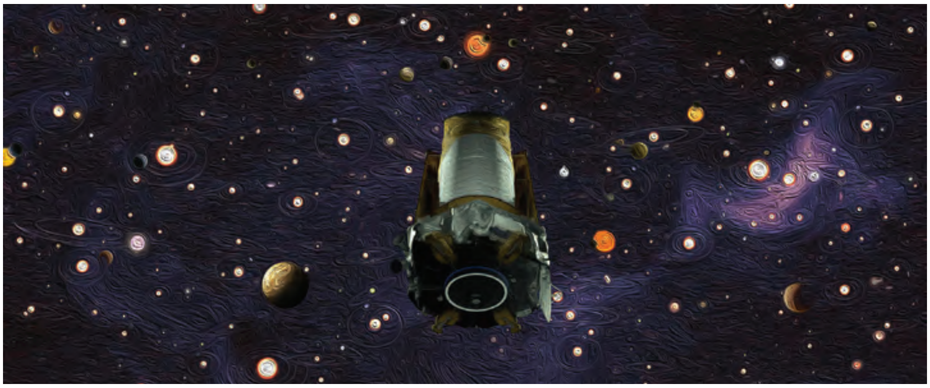
Kepler-1658b was the first exoplanet discovered by the Kepler space telescope, which found thousands of bodies over its lifetime using the transit technique. The telescope measured tiny dips in a star's brightness when a planet crossed in front of it.

Early in its mission, which ended in 2018, Kepler recorded such dips from Kepler-1658. However, astronomers had initially cataloged the star as belonging to the main sequence—stars like the Sun that are still burning the hydrogen in their cores. Researchers expected the star to be much smaller than it is, so the initial transit signals "didn't make sense," said Shreyas Vissapragada, a postdoctoral researcher at the Harvard-Smithsonian Center for Astrophysics and the lead author of the new study (bit.ly/Kepler-death-spiral). The transit indicated a planet roughly the size of Neptune, our solar system's third-largest planet. However, the system also produced a secondary eclipse as the planet passed behind the star. At Kepler-1658's distance, a Neptune-sized planet wouldn't be bright enough to see, so there would be no evidence of the secondary eclipse.

Kepler-1658b was discarded as a false positive and forgotten about.

"Suddenly, a close-in hot Jupiter made sense."

That is, until Chontos began looking at vibrations on the surfaces of stars in the Kepler catalog. Because the telescope kept a constant eye on the stars in its field of view, recording brightness levels every half hour or less, it detected "jiggles" caused by sound waves reverberating through the stars. Piecing



Kepler stares into a galaxy filled with its exoplanet discoveries in this illustration commissioned for the space telescope's retirement. Credit: NASA

together the vibrations—a technique known as asteroseismology—revealed details about the stars' interiors.

In the case of Kepler-1658, the vibrations showed that the star was much farther along in life—and hence about 3 times bigger—than expected. That meant the transiting planet was 3 times larger as well, making it big enough and bright enough to contribute to the system's overall brightness when it wasn't eclipsed by the star. "Suddenly, a close-in hot Jupiter made sense," Chontos said. "That discovery was completely accidental."

A hot Jupiter is a massive planet comparable in size to Jupiter—the giant of our own solar system—that orbits so close to its star that it is extremely hot. In this case, Kepler-1658b is about the size of Jupiter, but with almost 6 times its mass. "Even the combined masses of all the planets in [our] solar system don't add up to that," Chontos said. The planet orbits its star once every 3.85 Earth days, compared with an 88-day period for Mercury, the Sun's closest planet.

Changing a Planetary Clock

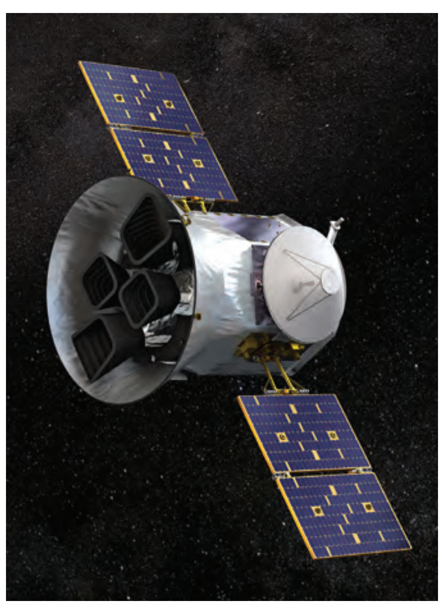
Kepler observed the system for about 4 years, so it obtained a good, but not perfect, measurement of the orbital period. It appeared to show that Kepler-1658b followed a steady path around the star.

At the same time Chontos was studying the system's vibrations, though, Vissapragada was conducting his own observations. (One night, in fact, he and Chontos bumped into each other during runs at the 200-inch Hale Telescope at Palomar Observatory, where both were looking at the system.)

Vissapragada obtained data from two Hale sessions plus three monthlong sets of observations by the Transiting Exoplanet Survey Satellite (TESS), a space telescope designed to discover and study exoplanets. When combined with the earlier Kepler data, the data provided a 13-year baseline of observations.

"They showed that the clock had changed—the transits were happening measurably earlier than they were predicted to occur," Vissapragada said. Kepler-1658b's orbital period was decreasing by 131 milliseconds per year (plus or minus about 20 milliseconds), suggesting that the planet will spiral into the star in about 2.5 million years.

The shrinking orbit is probably the result of tidal effects. "We think we know the total energy in the system," Chontos said. "The planet is depositing energy in the star, causing it to rotate faster and the planet's orbit to shrink." A small amount of the system's total energy could be dissipated in the planet as well, explaining some minor oddities in its orbit, Vissapragada added.



The Transiting Exoplanet Survey Satellite (TESS) is depicted in space in this illustration. Credit: NASA Goddard Space Flight Center

Ruling Out the Alternatives

An inspiral isn't the only possible explanation for the apparent change in orbital period, however. The timing could appear to change if the system were moving toward us, for example. By measuring the system's radial velocity—its motion toward or away from us—the team ruled out that possibility. It also ruled out the possibility that we see only part of the orbit's precession period—a "wobble" in the orbit. "We think we've ruled out all other probable causes," said Vissapragada.

"The evidence for inspiraling planets is plausible, and this paper presents good arguments for this being the case for this planet," said Girish Duvvuri, a graduate research assistant at the University of Colorado Boulder, who has studied the demise of exoplanets but was not involved in this project. "While I can't say they've exhausted all alternative hypotheses, they covered everything I can think of."

Even so, no one can say the fate of Kepler-1658b is sealed. The process of orbital evolution for planets around evolving stars is poorly understood, so several outcomes are possible.

"The whole dissipation process is very complicated," Chontos said. "It involves the obliquity, eccentricity, distance—all these different aspects of the orbit that can change over time. While it's going inward now, there's nothing to say that the orbit won't circularize and its migration will stop—just halt. At some point, the planet might even migrate outward. But right now, that's all just speculation."

The astronomers said they hope to narrow down the possibilities with additional observations of the system by TESS and other ground- and space-based telescopes. And they said that finding similar systems will help as well.

"We need to look at more of these systems to pin down exactly how that evolution works," Vissapragada said. "TESS should give us a lot more examples over the next decade, so we'll have a fairly large sample to see if this mechanism is common."

By **Damond Benningfield,** Science Writer