How much water would a self-sustaining moonbase need?

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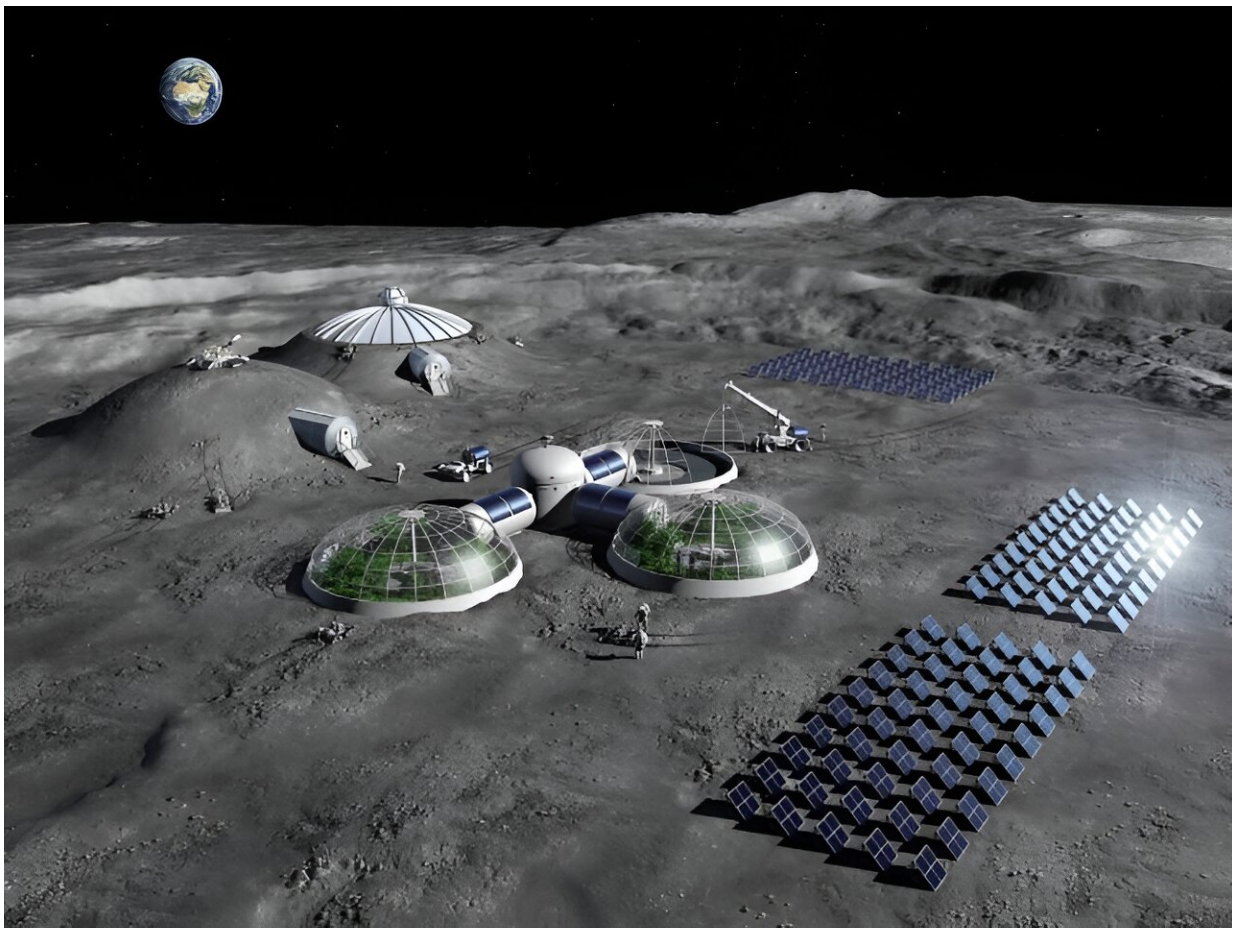

Artist rendition of a future lunar base. Credit: ESA - P. Carril

As humanity returns to the moon in the next few years, they're going to need water to survive. While resupplies from Earth would work for a time, eventually the lunar base would have to become self-sustaining? So, how much water would be required to make this happen?

This is what a study recently posted to the *arXiv* preprint server hopes to address as a team of researchers from Baylor University explored water management scenarios for a self-sustaining moonbase, including the appropriate location of the base and how the water would be extracted and treated for safe consumption using appropriate personnel.

Here, Universe Today discusses this research with Dr. Jeffrey Lee, who is an assistant adjunct professor in the Center for Astrophysics, Space Physics & Engineering Research at Baylor University, and lead author of the study, regarding the motivation behind the study, significant results, the importance of having a self-sustaining moonbase, and what implications this study could have for the upcoming Artemis missions. Therefore, what is the motivation behind this study?

Dr. Lee tells Universe Today, "This paper is actually an eclectic diversion for me from my astrophysics research on primordial black holes, early universe cosmology, breakthrough propulsion physics, and my geophysics research on asteroid impacts. If human missions throughout the solar system, particularly to Mars, are to be realized, then a permanent lunar facility seems to be a logical early step."

For the study, the researchers investigated water management requirements for a 100-person self-sustaining lunar base measured at 500 m x 100 x 6 m (1640 ft x 328 ft x 20 ft), including the location of the lunar base near water ice deposits, the technology required to convert the water ice to water vapor (since liquid water can't exist on the moon), and the technology required for water treatment and recovery that would result in safe consumption for the 100-person base. The study used the current water usage estimates for American households, which is approximately 100 gallons per day (GPD) per person, which includes cleaning, cooking, drinking, flushing toilets, and washing clothes.

Additionally, the researchers examined the amount of water required for agricultural, technical, and overall needs for the lunar base. Regarding the location of the lunar base, the researchers deduced that the best location for the base would be either near, or exactly on, the Shackleton-de Gerlache Ridge, which is located at 89.9°S 0.0°E, or almost directly on the lunar south pole. The reason this location is ideal for water ice deposits is because Shackleton Crater resides within a permanently shadowed region (PSR), meaning it is shrouded in permanent darkness due to the moon's small axial tilt, and water ice has potentially built up over billions of years.

In the end, the team concluded the water requirements for the 100-person lunar base for human, agricultural, and technical needs are 12.3, 72, and 2 acre-feet per year. For context, one acre-foot is equivalent to approximately 326,000 gallons, so a 100-person lunar base would need more than 4,000,000 gallons per year for human needs, more than 23,000,000 gallons per year for agricultural needs, and 652,000 gallons per year for technical needs. So, based on these findings, what were the most significant results from this study, and what follow-up studies are currently in the works or being planned?

Dr. Lee tells Universe Today, "There is good evidence that sufficient water exists on the moon to support a permanent lunar colony, and the acquisition, treatment, and distribution of the lunar water can be achieved with current technology. An appropriate administrative structure will be necessary to oversee all aspects of lunar water. The relative scarcity and management of water on the moon can potentially provide insight for improving the management of water on Earth. The next study for my group will be to investigate the ways in which the management of lunar water could help to improve terrestrial water management. However, the timeline for this research is yet to be determined."

The study discusses in-situ resource utilization (ISRU), which is using available, on-site resources for both sustainability and survivability. In this case, using water ice deposits on the moon, and specifically near the south pole of the moon, to meet the water needs of a 100-person, self-sustaining lunar base. The potential for NASA using ISRU has gained considerable traction in the last few years since sending water from the Earth to the moon could prove to be extremely costly. But aside from the financial risks, if a resupply mission gets delayed or fails on the way to the moon, the crew could face significant danger. Therefore, learning to "live off the land" for a lunar base could prove to be a viable, long-term option for mitigating the need of resupply missions from Earth. But what additional importance could a self-sustaining moonbase also provide?

Dr. Lee tells Universe Today, "Over the years, there has been a groundswell of excitement at the prospect of colonizing Mars. Indeed, at present, we are conceivably able to mount a short-term human voyage to the Red Planet in which the astronauts would collect samples, conduct experiments, plant flags, and when the next launch window occurs, return to Earth. However, the permanent colonization of Mars is much more ambitious and challenging. Mars is much farther away than the moon, requiring nine months to get there and a round trip time of 21 months (a 3-month stay on Mars is needed until the next launch window arrives)."

NASA's goal is to send humans to Mars through the agency's moon to Mars Architecture, which is an elaborate, years-long endeavor to develop the necessary technologies on the moon for use during a crewed mission to the Red Planet. This includes science, infrastructure, transportation, habitation, and operations, just to name a few. However, as noted, while we can (possibly) send humans to the Red Planet for short-term stays with our current technology, a long-term human presence on Mars would require significantly more time and resources.

Dr. Lee tells Universe Today, "Beyond low Earth orbit, the moon is a logical next destination. Lunar colonization is technologically achievable, and in comparison to Martian colonization, it is far easier. Being capable of establishing a moonbase seems like an obvious prerequisite for establishing a Mars base. Furthermore, the moon would be an excellent jumping off point for further solar system colonization, including potentially the eventual establishment of small colonies in the interiors of Near-Earth Asteroids. Additionally, some have suggested that the moon is an ideal location from which the interception of Earth-bound asteroids could be conducted."

This study comes as NASA's Artemis program plans to land the first woman and person of color on the lunar surface in the next few years. The current landing sites of the Artemis missions are near the south pole to access nearby water ice deposits within the aforementioned PSRs and could be ideal to develop ISRU technologies that can also be used on future Mars crewed missions, as well. Therefore, what implications could this study have for the upcoming Artemis missions?

"Short term lunar visits, such as the planned Artemis missions would not require lunar water," Dr. Lee tells Universe Today. "In these instances, sufficient water could be brought from Earth. However, if at some point in the future, a lunar colony were to become a priority, future Artemis missions could serve to provide valuable in situ information about the presence and abundance of lunar water, particularly at the lunar south pole and in proximity to the Shackleton Crater (an ideal area for a moonbase)."

More information: Jeffrey S. Lee et al, Water Management Considerations for a Self-Sustaining Moonbase, *arXiv* (2024). DOI: 10.48550/arxiv.2405.14100

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