Water electrolysis propulsion could be the first use-case for a resource mined in space!

Ice2Thrust: An end-to-end ISRU demonstration of sustainable water-based in-space propulsion

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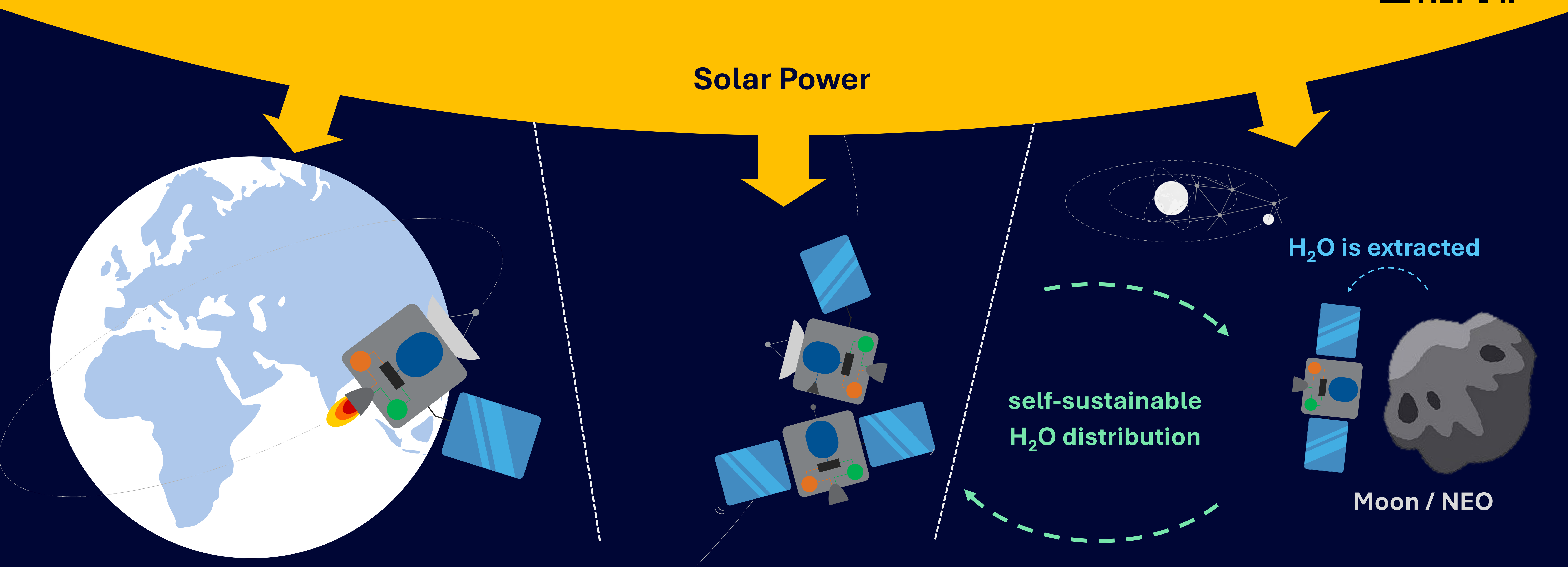

1. Solar-Electric Water Electrolysis Propulsion

2. Autonomous Proximity/Docking Operations and Propellant Refilling

3. In-space Water Extraction and Utilisation

Abstract

Water is one of the most accessible and abundant resources in the solar system. The presence of water has been detected on the lunar surface (Reiss 2024) and asteroids (Arredondo et al. 2024), both promising target destinations for thermal ice mining. Combining this with Water-Electrolysis-Propulsion (WEP) technology can form the basis of a self-sufficient space mobility architecture. As liquid water is non-toxic and easy to handle, this system simplifies in-orbit refilling as well as outperforms traditional storable propellants in terms of specific impulse.

The EIC-funded project "Ice2Thrust" (2024-2027) addresses several open research questions in the fields of water extraction, propulsion systems, and autonomous spacecraft operation across a team of European research institutions and industry.

A major project goals is the **end-to-end demonstration** of extracting, processing, and utilizing water ice to generate thrust under relevant conditions. Water will be extracted in vacuum using simulated solar radiation, captured, and transferred to an electrolyser. The gases will be used in a chemical thruster, aiming to demonstrate the ISRU chain and mature it to a **TRL of 5 to 6** for the first time.

References

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Thermal Ice Extraction

Lunar volatiles can be extracted using thermal or mechanical processes. Sunlight is abundant and readily available in space. Limited reach into the subsurface was reported for surface heating (Wasilewski 2021). Concentrated solar heating experiments show promising preliminary results and potential increased sublimation rates (Farr et al. 2025). The system will be investigated both numerically and experimentally. State-of-the-art physical models for coupled heat and mass transfer (e.g. Reiss 2018) will be used for numerical investigation of the extraction process.

Synergies with WEP:
- Electrolyzer is on the spacecraft → plant produces liquid water
- Thermal extraction is a simple architecture to generate water compared to other approaches

Extraction-focused research:
- Temperature field inside the regolith–ice mixture
- Interaction of volatile vapor and cold trap
- Efficiencies, power demand, scaling laws

System-focused research:
- Integration into WEP architecture
  → Interfaces & operations?
- Water purity (achievable and acceptable)

On the Moon?

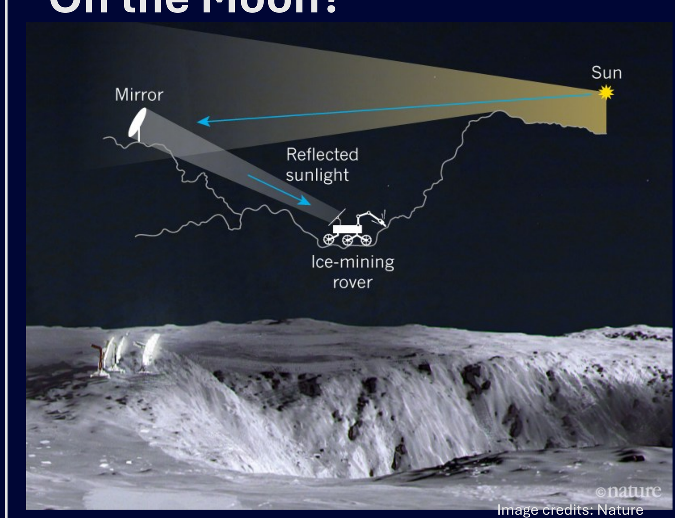
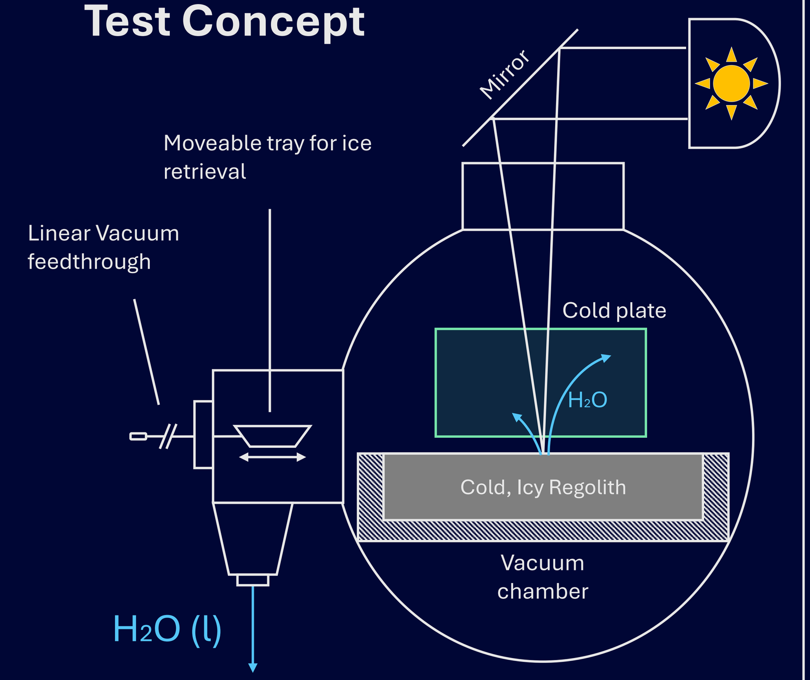


Image credits: Nature

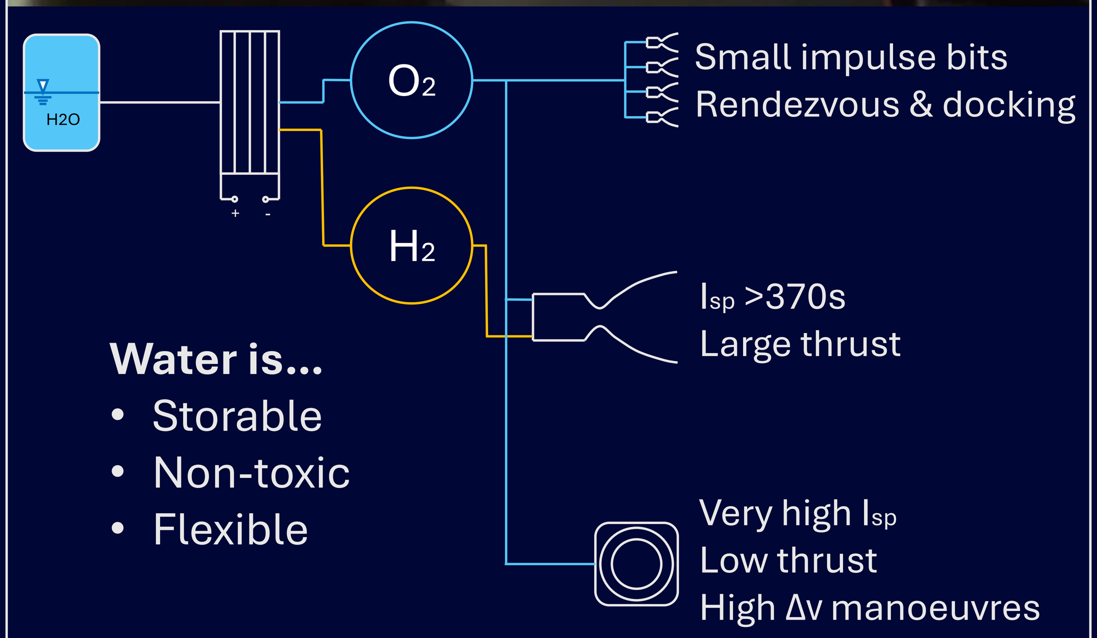
Test Concept



Coupled Test

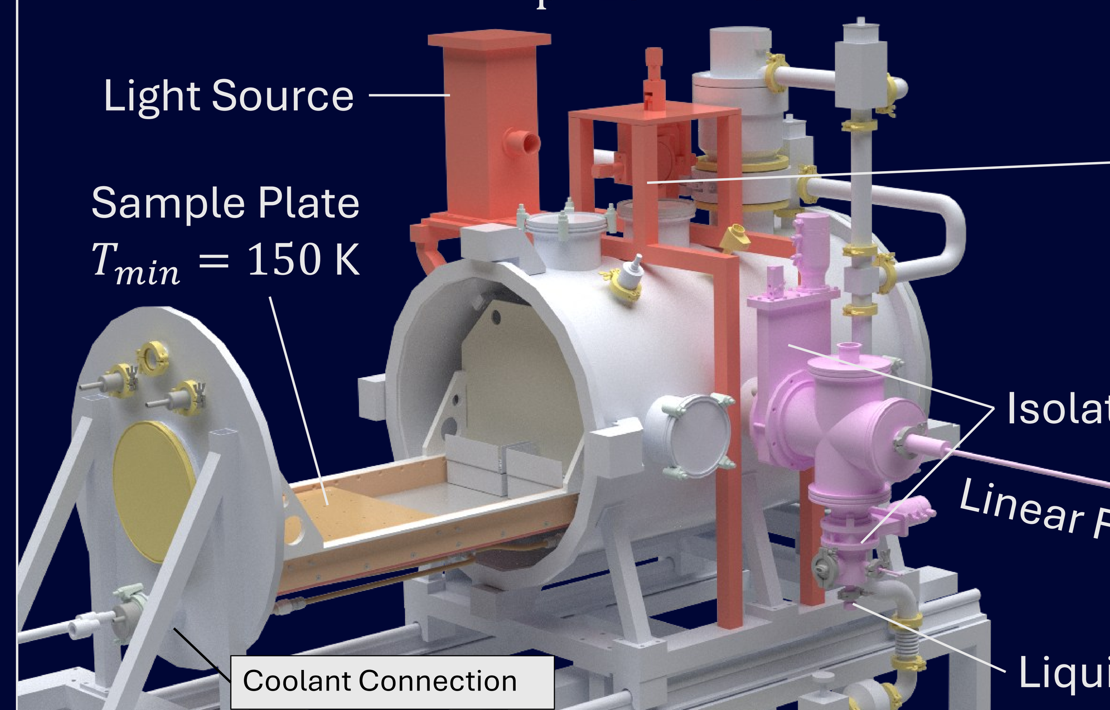
Water Electrolysis Propulsion

Hot-fire test of a transpiration-cooled chemical thruster prototype (Image: S. Dengler, TUM)

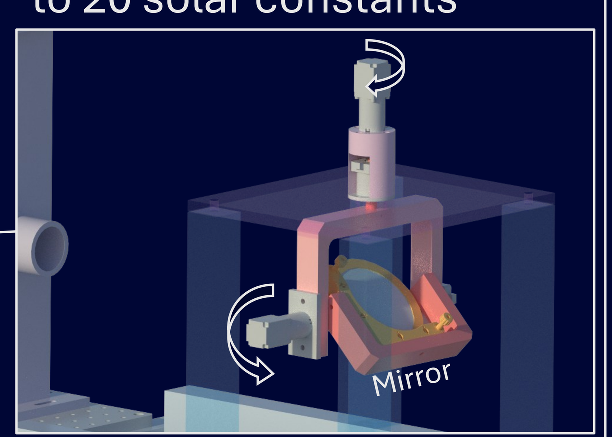


Water is...
- Storable
- Non-toxic
- Flexible

Challenges:
- Chemical thruster cooling (~MW/m^2 heat loads at throat) (Dengler et al. 2024)
- Achieving sufficient water purity for electrolysis
- PEM electrolyzer for space environment: Compact, lightweight, reliable (Heizmann et al. 2023)
- Docking adapter for water transfer



Movable light beam for up to 20 solar constants



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