Lunar Water Filtration System

Ayesha Farooq, Priyanka Mahi, Deborah Nguyen,
Danna Nguyen Pham, Danielle Parks, Georgia Voncina

What is Lunar Water?

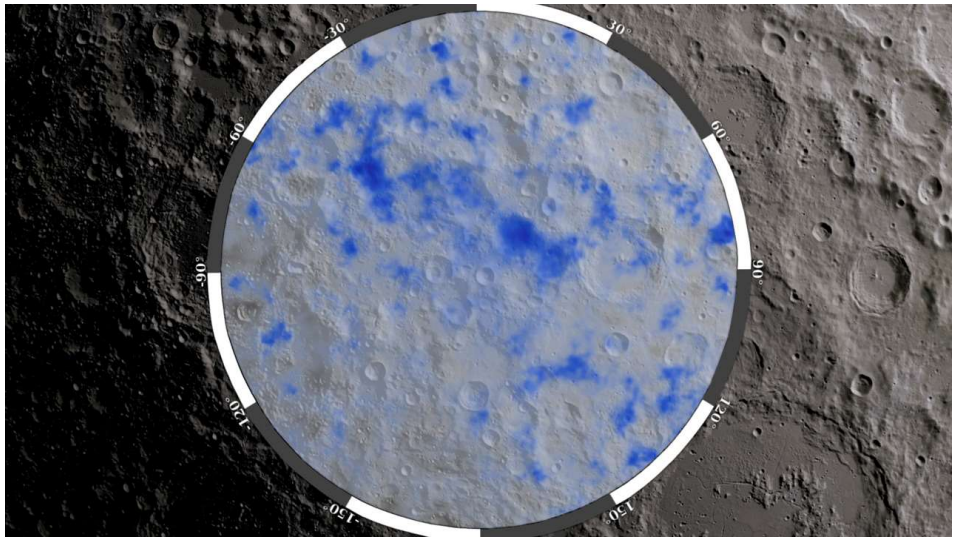


Figure 1: Possible Deposits of Ice Water on the Moon's South Pole from NASA's Lunar Reconnaissance Orbiter *Credit: NASA*

Frozen water deposits can be found underneath the moon's surface within lunar dust and rock (regolith).

Water can be extracted from the Permanently Shadowed Regions of the moon's south pole.

Pure water can be outputted by adapting filtration methods to the lunar environment to remove water from regolith and contaminants.

Objective and Execution

The objective of this project is to create a filtration system part of a larger lunar water processing plant capable of producing 2500-10,0000 L of pure water. Water is filtered from a 95% lunar regolith and 5% pure water mixture which can be sold for fuel or consumption.

Lunar Water Process

Water is extracted at extremely cold temperatures from lunar regolith

Water is transported to an autonomous processing facility

Water is de-frosted and filtered

Materials are stored and then sold

Why Develop Water on the Moon?

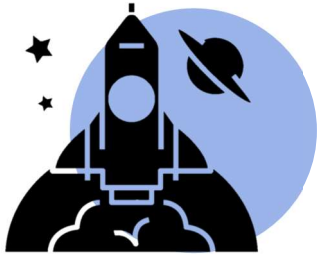
Demand

Our Value

[1]

$206 Billion USD market for water in space over the next 30 years

(Plate, 2019)



Economic growth in the space industry including tourism

Affordable rocket fuel extracted from pure water

[2]

Potable water for lunar habitants

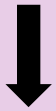
Design Specifications

Constraints

Environment

Extreme Temperature Range of -232 °C to 127 °C

Ambient Pressure of 0 Pa



Lunar Gravity of 1.62 m/s^2

14 Day and Night Cycle

Design

Weight Constraint of 1000 kg

Power Constraint of 10 kW

Maximum Shipping Volume of 450 m^3

Limited Maintenance to 2x a year

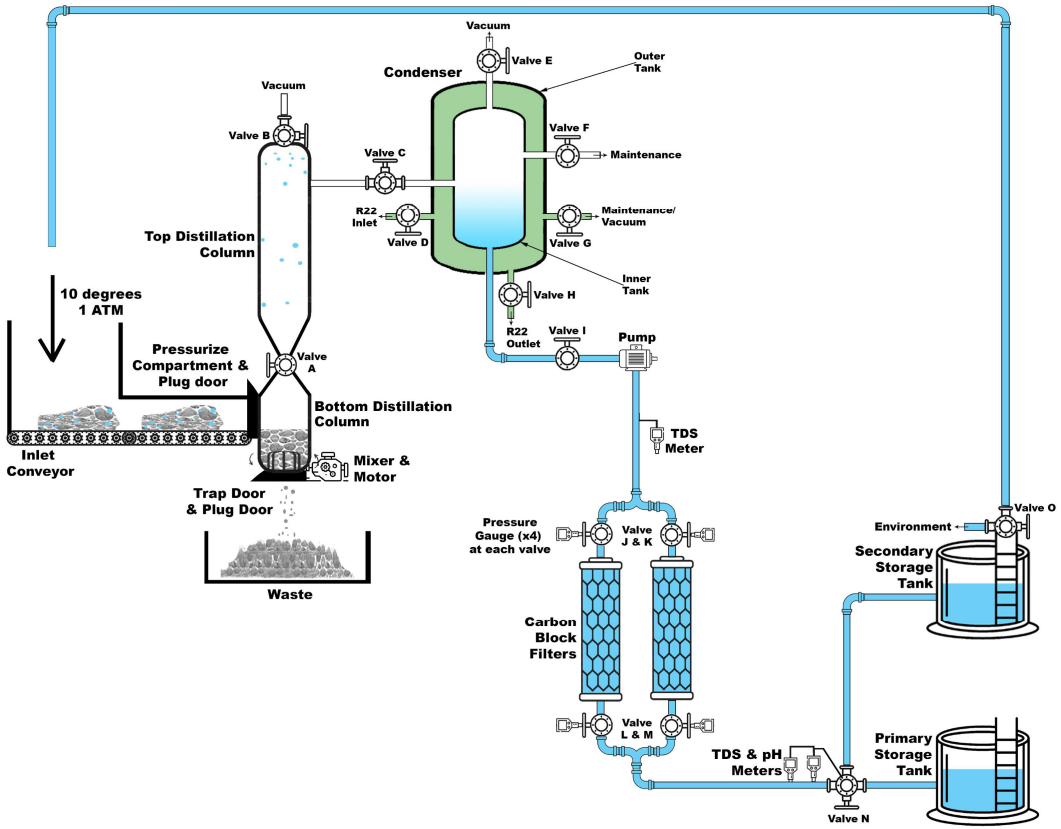
Performance

Water Quality

pH of 6.5-8.5

Total Dissolved Solids (TDS) Reading of 500 ppm or less

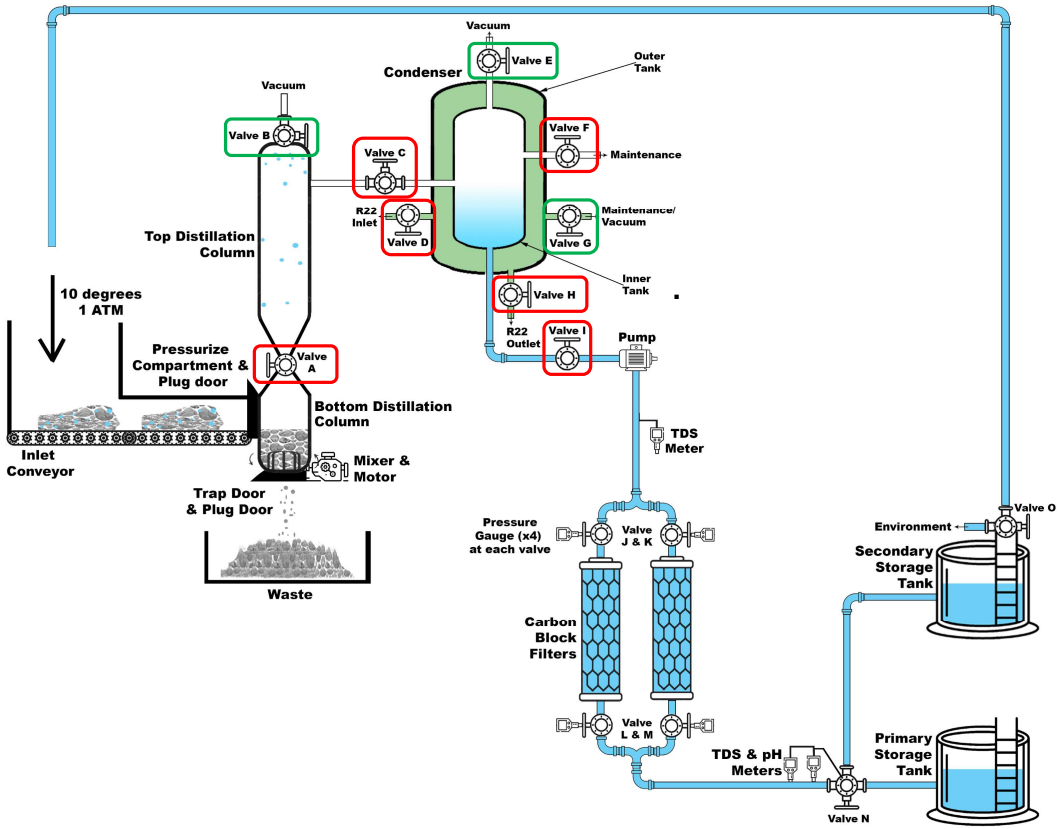
Filtration System



Design Features

- Double filtration methods ensure higher water quality
- Automatic testing ensures clean water is not contaminated
- Lunar vacuum atmosphere utilized to reduce power consumption
- System operates underground to mitigate adverse temperature changes
- Refrigerant 22 (R22) is used as the coolant for the condenser
- Batches of mixture ensure optimal water recovery

Filtration Process



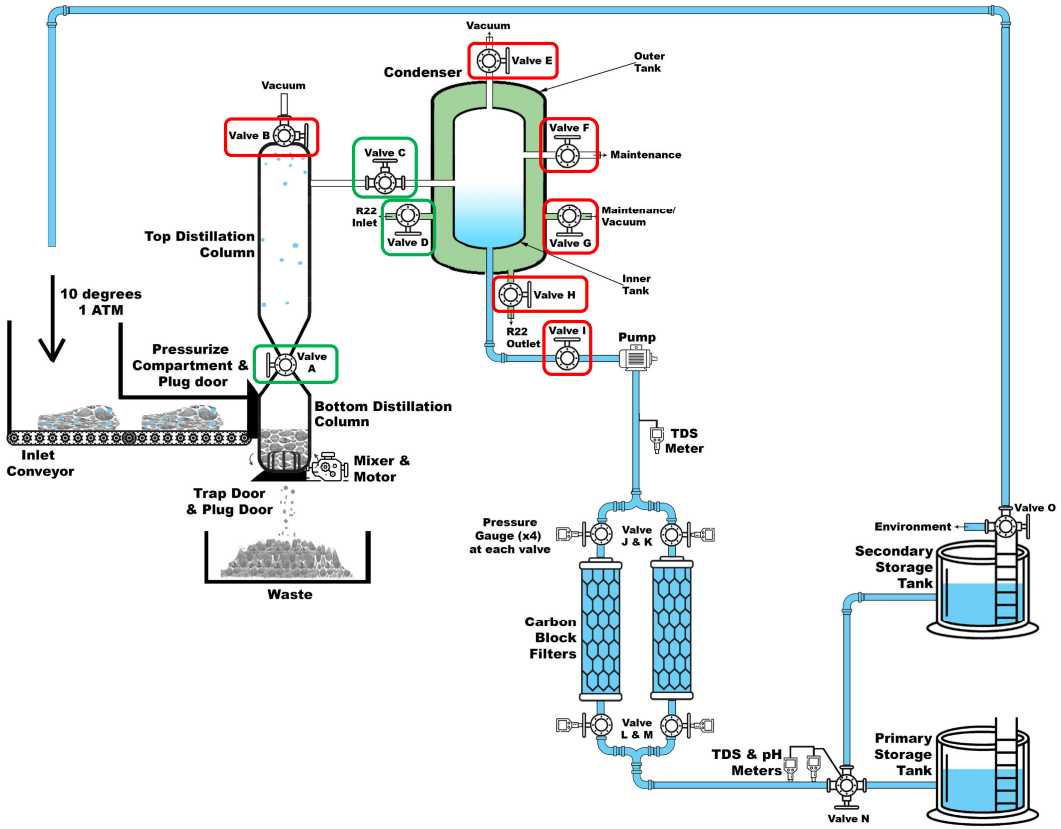
1 Vacuum the system while the lunar regolith water mixture is prepared.

Vacuuming the system cleans it after each batch and aids in distilling the water

Valve Open

Valve Closed

Filtration Process



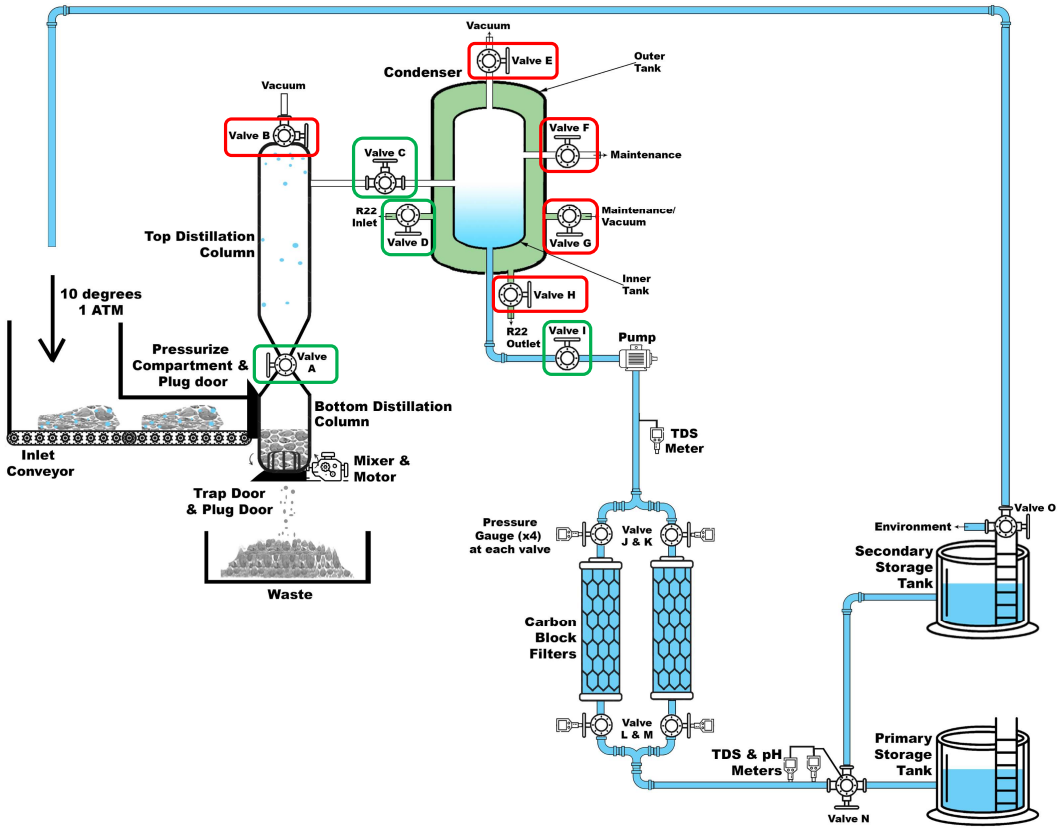
2 Water is evaporated and separated from the mixture while the condenser is cooled.

The vacuum decreases the pressure and evaporates the water. R22 fills the outer tank of the condenser to cool the vapor.

Valve Open

Valve Closed

Filtration Process



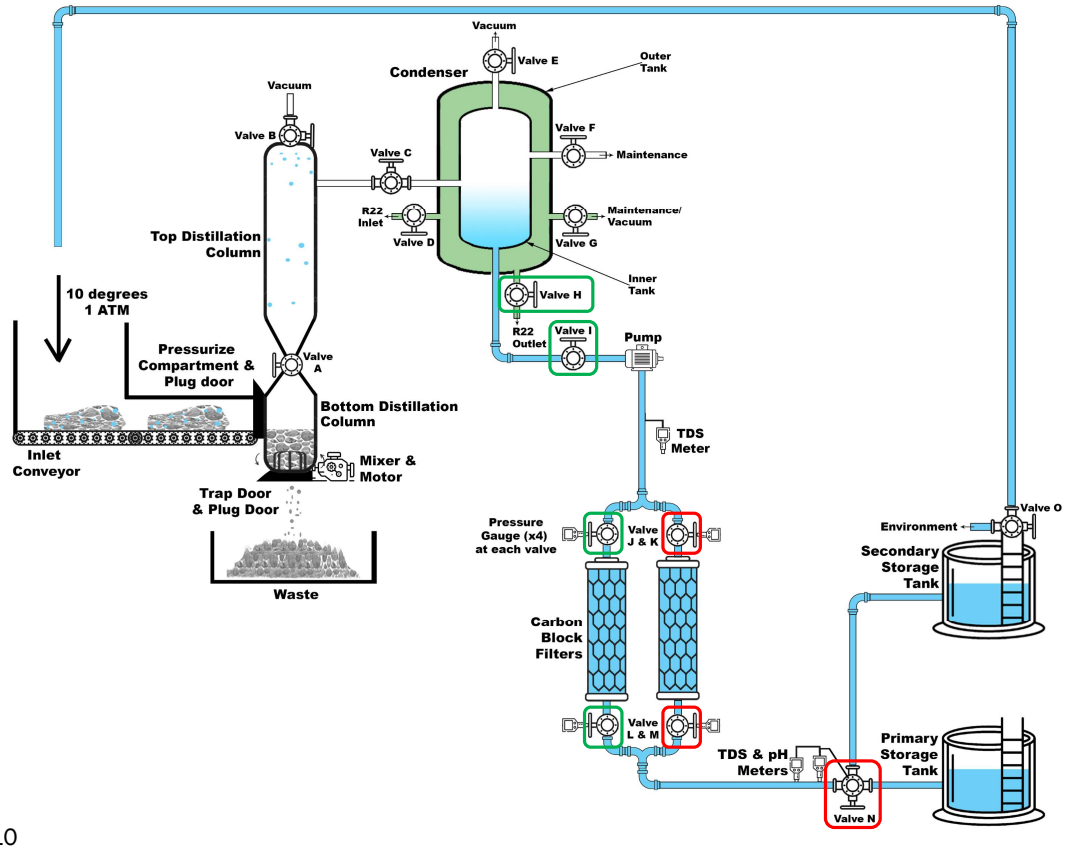
3 R22 lowers the temperature, so the water vapor condenses to a liquid in the inner tank.

R22 enters at -4℃ to cool down the system. Water enters into the inner cylinder to be cooled.

Valve Open

Valve Closed

Filtration Process



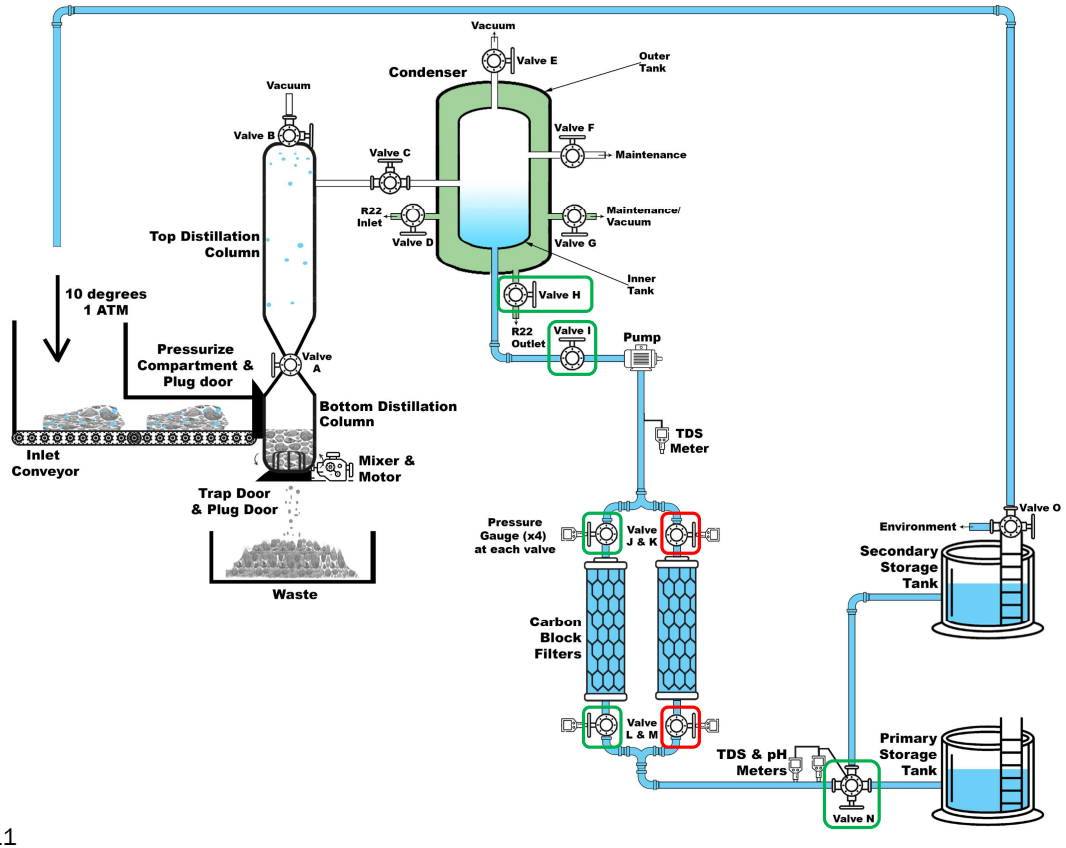
4 Liquid water is pumped to the Carbon Block Filters to be further purified.

An additional filter is placed in case of failure. R22 is removed from the system after the water condenses.

Valve Open

Valve Closed

Filtration Process



5 Water is tested. If it meets the pure water requirements it is flown to the primary storage tank.

Water that is not clean, flows to the secondary storage tank and is filtered again or removed.

Valve Open

Valve Closed

Conceptual Design Conclusions

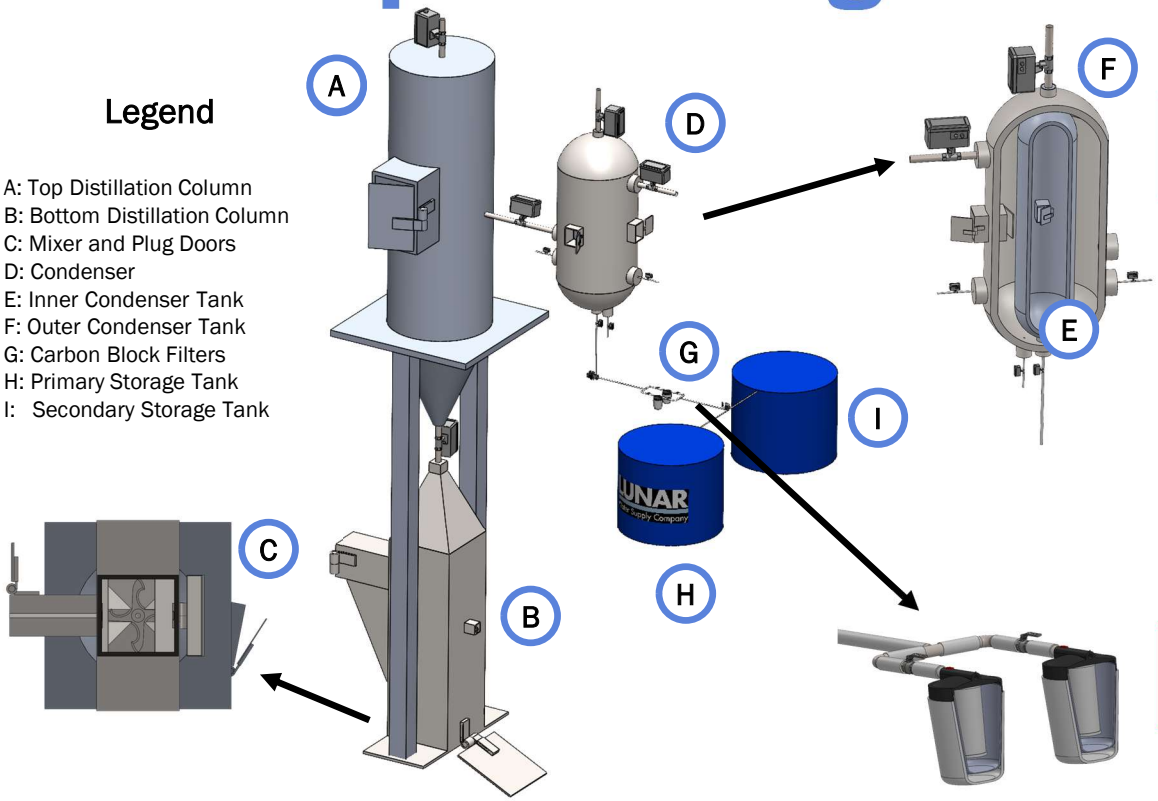


Figure 2: Conceptual Design Magnified with Cross Sections

Results

- Simulation filters all regolith and outputs 100% water
- Power consumption is 6.4 kW
- Shipping volume is 95 m^3
- Additional pipes and doors creates easy maintenance

- Exceeded weight limit so assembly can withstand wider temperature range

Prototype and Experiment Conclusions

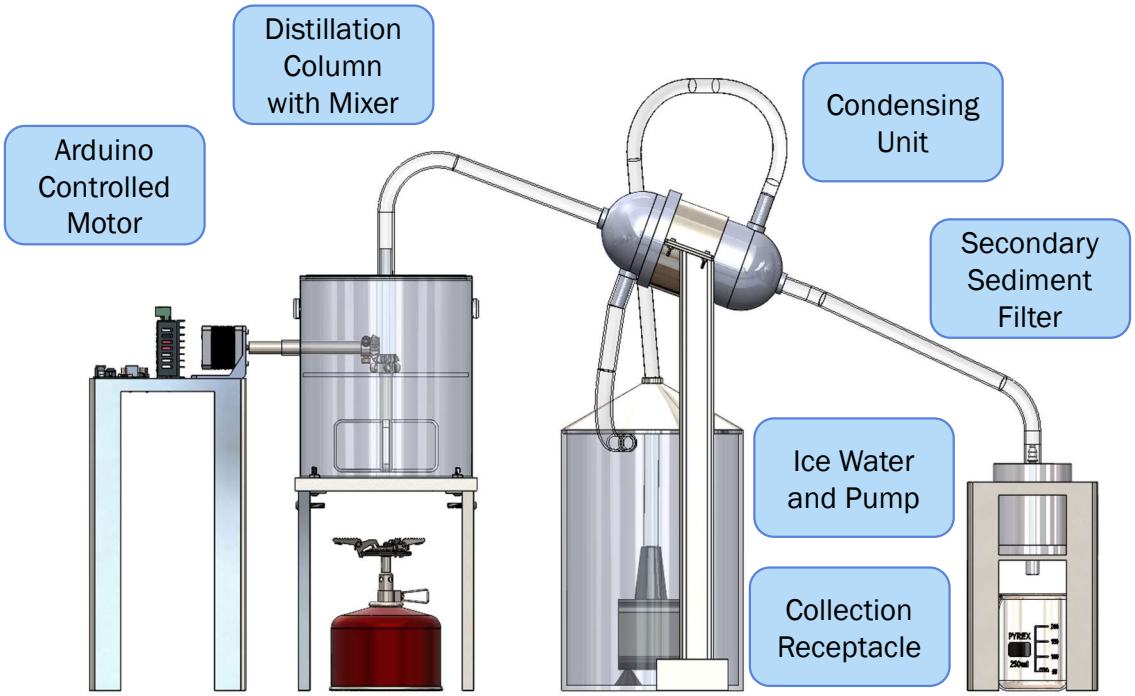


Figure 3: Prototype SolidWorks Model with Labels

Results

- pH of 7.29
- TDS reading of 83 ppm

Deviations from the Conceptual Design

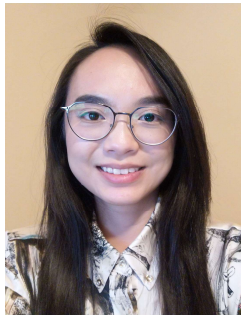
- Temperature driven distillation column
- Ice water coolant

Note: Deviations made since testing was not completed in a lunar environment

Team

Ayesha Farooq
Engineering Analysis

Priyanka Mahi
Engineering Design



Deborah Nguyen
Prototype Design & Manufacturing

Danna Nguyen Pham
Project Manager

Danielle Parks
Prototype & Procurement

Georgia Voncina
Process Engineering & Simulations

Sponsor

LUNAR
Water Supply Company

References

Sources

Plate, J. (2019). *Conceptual Economic Study for Lunar Water Mining*. Watts, Griffs and McOuat.

Websites Icons:

[1] *[Market Share] by [Gregor Cresnar], from the Noun Project*: https://thenounproject.com/icon/market-share-252379/

[2] *[Silhouette icon of woman drinking a glass of water. Concept of drinking water head in glass with hands. Thirsty man isolated on a white background. Great for mineral water logo icons. Vector Pro Vector] by [agussetiawan99]:* https://www.vecteezy.com/vector-art/13087635-silhouette-icon-of-woman-drinking-a-glass-of-water-concept-of-drinking-water-head-in-glass-with-hands-thirsty-man-isolated-on-a-white-background-great-for-mineral-water-logo-icons-vector

[3] [Underground House free icon]: Flaticon.com'. This cover has been designed using images from Flaticon.com https://www.flaticon.com/free-icon/underground-house_4047355

[4] [Refrigerant]: Flaticon.com'. This cover has been designed using images from Flaticon.com https://www.flaticon.com/free-icon/refrigerant_5098308