

Solar Assisted Reusable Rocket System

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Abstract— The growing demand for cost-effective and environmentally sustainable space transportation has encouraged the development of reusable rocket systems and renewable propellant technologies. This paper proposes a solar assisted reusable rocket system capable of producing its own propellant using renewable energy. Solar panels generate electricity that powers the electrolysis of water to produce hydrogen and oxygen. Hydrogen can be used directly as rocket fuel or converted into methane through a methanation process, while oxygen serves as the oxidizer. The generated propellants are stored in cryogenic tanks and used in the rocket engine for combustion to produce thrust. The reusable rocket design enables recovery and multiple launches, significantly reducing operational costs and environmental impact.

Keywords— Solar energy, reusable rockets, electrolysis, hydrogen fuel, methane propulsion, renewable propulsion.

I. INTRODUCTION

Space exploration has expanded rapidly in recent years, increasing the need for efficient, economical, and environmentally friendly launch systems. Conventional rockets rely on fossil-based propellants and expendable designs, which result in high operational costs and environmental impact. Reusable rocket technology has emerged as a promising solution to reduce launch expenses. Solar energy can be converted into electricity using photovoltaic panels and used for water electrolysis to generate hydrogen and oxygen.



Fig. 1.

Hydrogen–oxygen propulsion provides high efficiency and clean combustion, while hydrogen can also be converted into methane using carbon dioxide through the Sabatier reaction.

II. LITERATURE REVIEW

- Solar-Based Electrolysis for Hydrogen and Oxygen Production

- Juodkazyte et al. (2016)

Title: Solar water splitting: efficiency discussion

This study analysed **solar-assisted electrolysis efficiency** and showed that combining solar cells with electrolysis can achieve **~10% solar-to-hydrogen efficiency**. The work emphasizes that separating solar energy capture and electrolysis improves durability and efficiency, which is beneficial for **long-duration reusable rocket systems**.

- JETIR (2023)

Title: Green hydrogen production using electrolysis

This paper explains the **fundamental electrolysis process**, where electrical energy (from solar power) splits water into hydrogen and oxygen via redox reactions. It confirms that **renewable-powered electrolysis is a key pathway for sustainable propellant production**.

- Hydrogen–Oxygen Propulsion for Reusable Rockets
- Ha et al. (2022)

Title: Development trend of liquid hydrogen-fueled rocket engines

Ha et al. reviewed modern hydrogen rocket engines and emphasized their **high specific impulse and efficiency**, making them suitable for advanced and reusable launch systems. The study also notes increasing interest in hydrogen due to **clean combustion and compatibility with renewable production methods like electrolysis**.

- Mane & Kunjir (2022)

Title: Cryogenic Propellant for Upper Stage Launch Vehicles

This study highlights that **liquid hydrogen and liquid oxygen (LH2–LOX)** are critical for high-performance rockets due to their superior efficiency. It also discusses the importance of **thermal management and system optimization in reusable launch vehicles**.

- Methane–Oxygen Propulsion for Reusability

- AIAA (Cantwell et al., 2013)

Title: In-Situ Propellant Production for Future Mars Missions

This study discusses **methane–oxygen (methalox) propulsion** and highlights the use of **electrolysis combined with the Sabatier process** to produce methane and oxygen. The research shows that methalox systems are suitable for **in-situ**



production and reusable missions, especially for planetary exploration.

- **ESA / ArianeGroup (Prometheus Program, 2017–present)**

Concept (from literature and reports):

Research on methane-fueled engines (e.g., Prometheus) shows that **LOX–methane systems are optimized for reusable rockets** due to:

- Cleaner combustion
- Reduced engine wear
- Lower operational cost

This supports the adoption of methane in **next-generation reusable launch vehicles**.

- Electrolysis and In-Situ Resource Utilization (ISRU)
- NASA MOXIE Experiment (2021–2023)

The MOXIE experiment demonstrated **oxygen production using electrolysis (solid oxide electrolysis)** on Mars. This validates the concept of producing oxidizer **in-situ using electrical energy**, which can be extended to solar-powered systems for reusable rockets.

Hoeser (2018)

Title: *Mars Propellant Production Study*

This study discusses integrated systems where:

- Water is processed
- Hydrogen is used to produce methane
- Oxygen is generated via electrolysis

It highlights the feasibility of closed-loop propellant production systems for reusable rockets.

III. METHODOLOGY

A. Solar Energy Collection and Power Generation

High-efficiency photovoltaic (PV) solar panels are used to capture solar radiation and convert it into electrical energy. Solar concentrators may be incorporated to increase the intensity of sunlight reaching the panels, thereby improving electrical output. The generated DC power is regulated using power electronics circuits such as charge controllers and DC-DC converters to maintain stable voltage levels. Energy storage devices such as lithium-ion batteries or super-capacitors are integrated into the system to ensure continuous operation during periods of low solar radiation.

B. Water Electrolysis for Hydrogen and Oxygen Production

The electrical energy generated from solar panels powers an electrolysis unit. In this process, water molecules (H_2O) are split into hydrogen (H_2) and oxygen (O_2) gases using electrical current. Proton Exchange Membrane (PEM) or alkaline electrolyzers are typically used because of their high efficiency and reliability. Hydrogen produced in this stage serves as the primary rocket fuel, while oxygen functions as the oxidizer required for combustion.

C. Methanation (Sabatier Reaction) Process

In order to improve storage and handling characteristics, hydrogen can be converted into methane through the Sabatier reaction. In this chemical process, hydrogen reacts with carbon dioxide to produce methane (CH_4) and water. Methane is easier to store and transport compared to hydrogen and is widely considered a promising propellant for reusable rocket engines.

D. Propellant Compression and Cryogenic Storage

The produced hydrogen or methane and oxygen gases are compressed and stored in insulated cryogenic tanks. These tanks are designed to maintain extremely low temperatures required for liquefied propellant storage. Thermal insulation and pressure control systems are implemented to reduce propellant boil-off losses and maintain safe storage conditions.

E. Propellant Feed System

A propellant feed system consisting of pumps, valves, and pipelines delivers the stored fuel and oxidizer to the rocket engine. Flow control mechanisms regulate the mixture ratio of fuel and oxidizer to ensure efficient combustion. Sensors continuously monitor pressure, temperature, and flow rate to maintain safe engine operation.

F. Rocket Engine Combustion and Thrust Generation

In the rocket engine combustion chamber, fuel and oxidizer mix and undergo a high-temperature chemical reaction. The combustion process generates extremely high-pressure gases that are expelled through a converging-diverging nozzle. According to Newton's third law of motion, the expulsion of gases produces an equal and opposite reaction force known as thrust, which propels the rocket upward.

G. Reusable Rocket Recovery System

To improve sustainability and reduce launch costs, the rocket is designed with a reusable recovery mechanism. After payload deployment, the rocket stage returns to Earth using controlled descent techniques such as retro-propulsion, parachutes, or aerodynamic control surfaces. The recovered rocket stage can then be inspected, refurbished, refueled, and reused for subsequent missions.

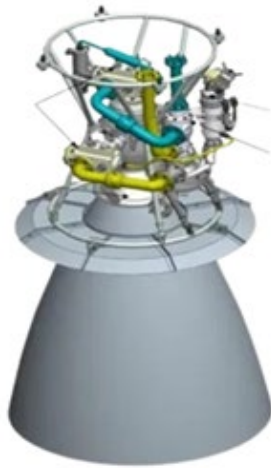


Fig. 6. Engine Nozzle

IV. RESULT

- Efficient solar-powered propellant generation system.
- High-performance propulsion using hydrogen–oxygen or methane–oxygen fuels.
- Reduced environmental impact through renewable energy utilization.
- Significant reduction in launch cost through reusable rocket technology.
- Feasibility of in-situ propellant production for future lunar and Martian missions.

V. CONCLUSION

The solar assisted reusable rocket system provides a sustainable and innovative approach for future space transportation. By integrating solar power generation, water electrolysis, methane synthesis, and reusable rocket technology, the system demonstrates the potential for environmentally friendly propulsion systems and cost-effective launch operations.

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