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Israel's Hydrogen Sector:

An Ecosystem in the Making - A Primer

With 2023 being the hottest year on record, with the average global temperature exceeded 1.37 °C higher than preindustrial levels,[1] finding sustainable solutions to help decarbonize the economy is becoming ever more urgent. The ability to decarbonize rests, in large part, in finding sustainable power sources that are clean, efficient, and scalable, and to reduce emissions in hard-to-abate sectors of the economy.[2] These efforts align with the goals set forth in the 2015 Paris Agreement,[3] aims to limit global temperature increase to well below 2°C above pre-industrial levels and make efforts to restrict the increase to 1.5°C above pre-industrial levels, thereby addressing climate change and its negative impacts.[4]

Achieving the goal of decarbonization is not solely reliant on one technology or energy source, but rather on a portfolio of diverse sources such as solar, wind, nuclear, and more.[5] Hydrogen is emerging as another significant contender in the pursuit of decarbonization.

A growing ecosystem of hydrogen technologies is rapidly building and maturing in Israel, driven by academic research, government support, and private sector investment, underpinning a multitude of recent technological advancements.

In this report, we explore hydrogen, use cases, and the technologies that are available in Israel to highlight this ecosystem's potential as a key destination for hydrogen solutions.

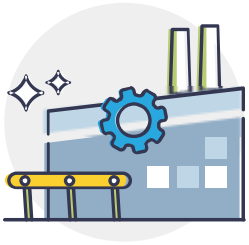
The Potential of Hydrogen

Hydrogen is the most abundant and lightest element in the universe. As hydrogen contains a high ratio of energy per weight unit, it has recently emerged as a potential source of renewable energy, able to help propel the shift towards a net-zero emissions energy system.[6] Hydrogen is produced through methods that enable isolating it from the compounds that contain it such as natural gas, coal, and water.[7] Hydrogen supply currently relies almost entirely on natural gas reforming and coal gasification which are highly carbon intensive processes.[8]

Hydrogen is often classified according to the type of process used to produce energy: When carbon emitted during hydrogen production is captured and either used or stored, the resulting product is "blue hydrogen".[9] When hydrogen is produced from renewable electricity via electrolysis[10] it is called "green hydrogen", which stands out as the most sustainable technology for clean hydrogen production. [11]

Both green and blue hydrogen are expected to play a central role in the future hydrogen economy.[12]

Clean hydrogen is recognized as a potential breakthrough technology when it comes to decarbonizing hard-to-abate sectors.[13] There are five key current and future applications for hydrogen:

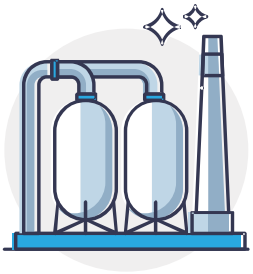


Industry

Hydrogen can replace carbon-intensive processes in industries, serving as a crucial feedstock and immediate solution for cleaner applications.[14]

Transport

Hydrogen's high energy-to-weight ratio makes it a promising solution for decarbonizing heavy vehicles like trucks, buses, and trains, with potential applications in aviation and marine transport.[15,16]

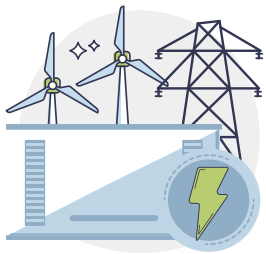


Long Term/High Volume Storage

Hydrogen's ability to be stored in large quantities for extended periods makes it an attractive option for seasonal energy storage, especially in salt caverns and large containers near demand centers for various sectors, including transportation and power.[17]

Grid Load Balancing

Hydrogen, particularly through electrolysers, can enhance grid flexibility by storing and transporting excess renewable energy, contributing to real-time balancing and addressing peak demands alongside other storage mediums like batteries and pumped hydroelectricity.[18]



Hydrogen also has commercial usages since, in its various forms (gas, liquid, solid state) serves as a versatile carrier (e.g., ammonia, liquid hydrogen, and liquid organic hydrogen) for export, unlike electrons which are limited to electric circuits.[19]

Given hydrogen's various applications and its potential to decarbonize hard-to-abate sectors, hydrogen demand is expected to grow in the upcoming decades from the current ~90 megatons per year.[20] According to Deloitte projections, based on the International Energy Agency, Net Zero by 2050 scenario, molecule-based energy carriers are expected to provide approximately 30-35% of total energy consumption by 2050, while hydrogen is likely to constitute approximately 35% of the molecular energy carriers. This means that approximately 10% of the total energy consumption in 2050 will be attributable to Hydrogen.[21]

Still, hydrogen as a solution for decarbonizing hard-to-abate sectors faces challenges to scale. The global hydrogen sector faces significant obstacles throughout its value chain, from production to end use applications. These challenges can be categorized as follows:

Upstream Challenges – Production:

The current hydrogen supply relies almost entirely on natural gas reforming and coal gasification, both highly carbon-intensive.[22] To drive hydrogen demand, there is a need for significant cost reduction in producing green and blue hydrogen, facilitating the transition from carbon-intensive to low-carbon hydrogen production. Increasing efficiency of both electrolyzers and carbon capture utilization and sequestration (CCUS) technologies,[23] along with reaching economies of scale, are key in driving down the unit cost of green and blue hydrogen, respectively. Thus, making it more economically attractive for adoption.[24]

Downstream Challenges – End-Use Applications:

For hydrogen solutions to proliferate, solutions that enable wider range of end use applications for hydrogen should be developed, as its current uses involve high CO2 emissions.[28] Clean hydrogen is not yet cost-competitive, hindering its economic viability compared to other energy sources or fossil fuel-derived hydrogen and impeding the growth of a global clean hydrogen market.[29] A particular emphasis is placed on the development of fuel cell systems, crucial for the efficient conversion of hydrogen back to electricity.[30] This pivotal development is integral to the broader utilization of hydrogen, especially in sectors such as transportation and stationary power.[31]

Midstream Challenges – Storage and Transport:

While boosting production capabilities take the center of attention, storage and transportation of hydrogen can be often overlooked.[25] Hydrogen needs to be compressed or converted into a liquid or solid to increase its density and make it more practical for storage and transportation. The conversion process is costly and can significantly add to the end price of hydrogen.[26] However, enabling the storage and transport of hydrogen over significant distances, while reducing transmission costs, is a key factor for wide-scale hydrogen adoption since hydrogen is not necessarily produced when and where it is consumed.[27]

Israel's Hydrogen Sector

Overcoming the challenges of the hydrogen value-chain can be made through implementation of new technologies, enabled by scientific and engineering breakthroughs. Israel is emerging as a unique technology hub for hydrogen, with many advanced solutions emerging and several enabling features taking shape that signal a focus on hydrogen within the local innovation ecosystem.

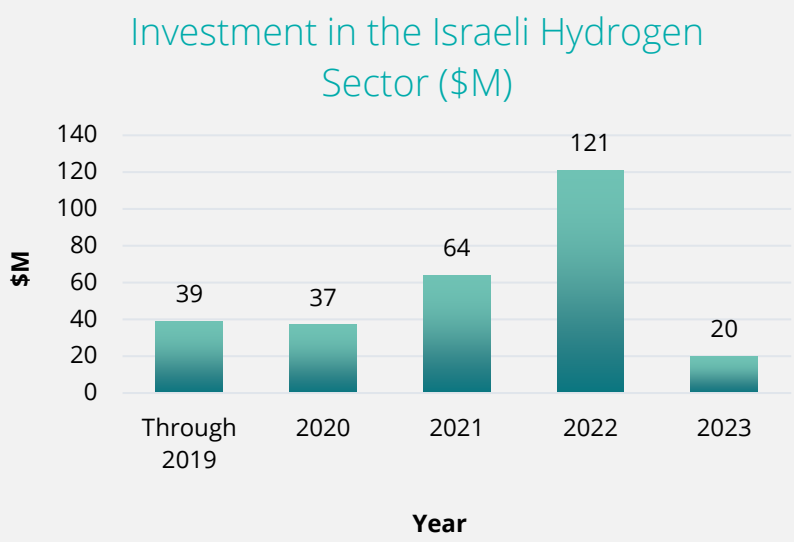
The thriving Israeli hydrogen ecosystem is led by a combination of different stakeholders. First, world-renowned research institutions and researchers, based on our assessment, are responsible for a meaningful number of hydrogen-related technologies in Israel, providing a strong scientific base for R&D that ultimately finds its way to the innovation ecosystem.[32] Second, Israeli government investments, grants, and strategic initiatives coming from the Israel Innovation Authority and the Ministry of Energy and Infrastructure underscore a national commitment to developing the domestic hydrogen economy.[33] Third, local corporates such as Bazan, Doral, ICL, Sonol, and Colmobil are actively advancing the local hydrogen ecosystem through investments, strategic partnerships with researchers, and pivotal infrastructure development, including fueling stations and production hubs.[34,35]

Fourth, Israeli hydrogen startups, totaling around 30, offer a diverse range of tech solutions spanning the entire hydrogen value chain. These innovations range from green and blue hydrogen production to storage and transit solutions, as well as diverse applications such as fuel cells, ammonia production, hydrogen-based drones, HVAC systems, and beyond.

These stakeholders often work together to accelerate the breakthroughs, validation and commercialization efforts of innovators and serve as enablers in the formation of startups. Such collaborative efforts exist in other subsegments of the Israeli innovation ecosystem, such as Cybersecurity and Healthcare, suggesting that hydrogen technologies can enjoy similar dynamics of growth.

Investors

One example underscoring the growth in the sector can be found in the investment landscape. With more than 50% of hydrogen-related startups founded after 2019, there has been exponential growth in fundraising with $121M invested in 2022, almost doubling the total amount of capital raised in the sector in 2021 ($64M) and more than tripling the amount of capital raised through 2019 ($37M). Although there was a significant decrease in investments during 2023 due to macroeconomic trends influencing the tech sector as a whole,[36] the hydrogen sector continues to demonstrate potential, capturing heightened interest from a growing number of investors (including both Venture Capital and Corporate Venture Capital), representing 37.5% of the total Israeli energy investors.[37] Moreover, 50% of the investors in the hydrogen sector are foreign investors, indicating an interest in the industry.[38]



* Through 2019 - it encompasses investments made before and up to the end of that year.

The value of the Israeli hydrogen innovation sector is showcased across the value-chain, as explored below:

Upstream Challenges - Production

A prominent example in the area of hydrogen production in Israel is H2Pro, an academic spin-off based on research conducted in the Technion University, that offers a disruptive system for large scale green hydrogen production, significantly reducing both electrolyzer equipment and operation costs.

Midstream Challenges – Storage and Transport

Hydro X offers a system for storing hydrogen in a non-toxic, non-flammable, and non-explosive water-based liquid, based on a process developed over many years of research at the Hebrew University of Jerusalem. The system improves energy efficiency by enabling charging and releasing energy at ambient temperature and low pressure, offering a solution to mitigate safety risks, reduce hydrogen storage costs, and increase energy efficiency.

Downstream Challenges – End-Use Applications

GenCell developed cost-efficient fuel cell technology for diverse applications like hydrogen-based EV charging stations and backup/off-grid power. It utilizes a simpler configuration and abundant metals, serving as an eco-friendly alternative to carbon-intensive options like diesel generators.

For a comprehensive overview of Israeli technologies across the hydrogen value chain, refer to the attached ecosystem map and the full report.

Summary

As climate change compels humanity to seek sustainable solutions with increasing urgency, we anticipate a surge in developments and interest within the hydrogen sector, further reinforcing its role in shaping a greener and more resilient future. Hydrogen being a molecular-based energy carrier (as opposed to electron-based) enables it to serve as a complementary solution to electrification in areas where it is otherwise limited, potentially serving as the missing link towards achieving Net Zero goals.

Israel's fast-growing hydrogen sector has significant potential in its ability to ideate solutions that address crucial obstacles across the hydrogen value chain and serve as a key contributor in the emerging global hydrogen economy. Developments in Israel's hydrogen sector, evolving alongside technological and commercial landscapes, establishes Israel as a pivotal player in global hydrogen advancements, drawing attention from global markets, investors, and multinational corporations.

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Israeli Hydrogen Ecosystem

Startups

Upstream Production

Boson Energy · Chiral energies · CO-ENERGY · H2 Energy Now · airovation technologies · H2PRO · Purammon · QD-SOL · ZCT · StandardCarbon

Downstream Applications

CARBONADE · AQUARIUS · FontoPower · NitroFix · GenCell · HydroLite · Luminescent Heat Engine · maygia · TURBOGEN CHP · HEVEN DRONES

Midstream Storage & Transportation

nugen · REFUEL · Electriq Global · FastSense · nanoscent · Hydrox · optiGain Quantum Optics Analysis

Investors

BAZAN GROUP · Breakthrough Energy · CAPITAL NATURE · DORAL Tech Ventures · HYUNDAI · ESIL environmental sustainability innovation lab · extantia · GROVE VENTURES · Elbit Systems · OTHER SOURCES ENERGY GROUP · TEMASEK · TDK TDK VENTURES · YARA · Contrarian Ventures · IN · OurCrowd · NGV NEXTGEAR VENTURES · TPY CAPITAL · ArcelorMittal · E44 VENTURES · NetZero Technology Ventures · qFund

Academia

BGN Ltd · BIRAD RESEARCH & DEVELOPMENT COMPANY LTD Bar-Ilan University · RAMOT TEL AVIV UNIVERSITY · TECHNION TECHNOLOGY TRANSFER · YEDA · YISSUM The Hebrew University Tech Transfer Company

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AICL · COLMOBIL CORP. · חברת החשמל · DOR · רשות החדשנות Israel Innovation Authority · EnergyCom.IL · Sonol · IGNITE THE SPARK · BIRD Israel-U.S. Binational Industrial Research and Development Foundation · Ministry of Energy and Infrastructure · CLIMATE FIRST · START-UP NATION CENTRAL · נתיבי הגז הטבעי לישראל ISRAEL NATURAL GAS LINES Infrastructure for Energy Independence · Taavura · quantum · EILAT EILOT Renewable Energy

Endnotes

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The companies in this report were selected through a meticulous process, supported by data from IVC Research Center, Startup Nation Finder, and PitchBook databases, based on discussions held with Israeli academic institutions. Additionally, a compilation of articles pertaining to the subject matter has been included for reference. It is imperative to emphasize that the chosen companies align with the report's publication date, acknowledging the inherent dynamism of the industry and the potential for frequent changes.

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